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THE ADJUNCTIVE USE OF PROGRAMMED INSTRUCTION IN HIGH SCHOOL CHEMISTRY

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled, "The Adjunctive Use of Programmed Instruction in High School Chemistry", submitted by Frank W. Jenkins in partial fulfilment of the requirements for the degree of Master of Education.

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ABSTRACT

Past research has shown that PI used adjunctively to CI has produced significantly greater achievement than CI alone. The present study has attempted to begin a search for the optimal method of presenting adjunctive PI by manipulating the amount of teacher direction (directed versus nondirected) and the time of presentation (preview versus review) when PI is used adjunctively to CI. The CI was held constant by having each of the three teachers use the adjunctive PI in all of the four ways defined by the 2 x 2 factorial design. The teachers were asked not to change their regular practices other than providing classwork and homework time for the completion of the PI assignments.

A programmed textbook which contained horizontally programmed chemistry materials was employed adjunctively to Chapters 13, 15 and 16 of the CHEM Study textbook. The programmed materials repeated the instruction of part of what the teachers presented by requiring the students to respond to programmed frames which provided a horizontal extension of the CI.

The data gathered consisted of Chapter 15 and 16 achievement test scores, student reactions to PI in general and to the manner in which the PI was presented, and teacher opinions on the use of PI adjunctively to CI.

A two-way analysis of covariance procedure using Form 3A SCAT scores as the covariate was employed with the Chapter 15 and 16 achievement scores as separate criterion measures. A significant

difference in achievement ($p < 0.05$) favouring the teacher-directed over the nondirected approach was obtained when the Chapter 16 achievement test scores were used as the criterion measure.

The students and the teachers indicated that on the basis of their experience in the present study adjunctive PI was regarded as beneficial to learning and should be used as a teacher-directed review to the CI. More teacher-direction appeared to be required for low ability students and for PI which varies considerably from the CI in terms of subject matter and terminology.

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CHAPTER I

THE PROBLEM

Background of the Problem

The background rationale for this study may be found in the history of programmed instruction (PI), in the need for generalizable research on PI, and in the relationship of PI to high school chemistry instruction.

The modern history of PI starts in 1954 with Skinner's article "The Science of Learning and the Art of Teaching." Skinner's linearly programmed teaching machines were not the first teaching devices available, but he was instrumental in defining a technology of teaching. Skinner attempted to integrate principles of learning with classroom practices using PI as the vehicle.

As reflected in research reviews, a rush of enthusiasm for PI occurred between 1960 and 1964. Schramm (1964) reported that one hundred and sixty-five of the one hundred and ninety PI studies that he reviewed appeared after 1959. Fifty percent of these studies dealt with presentation variables, thirty percent dealt with response mode (i.e. eighty percent were PI-versus-PI studies), and a large number of the remainder were PI-versus-conventional instruction (CI) studies.

Unfortunately the state of research on PI has not appeared to progress much since the mid 1960's. This situation is illustrated in Chapter II. An explanation is attempted in terms of "practical" generalizability below.

Pressey (1962) summarizes the period of research between 1960 and 1964 by noting that PI was used primarily as a review adjunct (supplement) to CI before the 1960's whereas during the early 1960's PI became the initial and primary presenter of learning material. It was a case of "enthusiasts carry(ing) a new idea to extremes." (Pressey, 1962:3). Two variables had been changed simultaneously--PI was now used to initially present rather than review subject material, and was now used as the primary mode of presentation rather than as an adjunct to the teacher.

Stolurow (1969:1020) concluded from his review of PI research that "research on PI leaves no doubt that students who use it learn. The only course of action for areas of application is how to use PI most effectively." The types of applications of PI which have been made vary quite considerably. The present study attempts to investigate a type of application of PI which could conceivably receive wider acceptance in high school chemistry classrooms than studies which compared PI to conventional instruction.

Wider acceptance of research recommendations by classroom teachers is discussed in the present study as a function of the "practical" generalizability of research results. "Practical" generalizability as used in the present study is different from the term "generalizability" used by Campbell and Stanley. Campbell and Stanley (1966:5) suggest that generalizability asks the question: "To what populations, settings, treatment variables, and measurement variables can this effect be generalized?" They then describe the research design factors which may jeopardize the desired generalizability

of results. Because of an interaction involving the treatment and some other variable, the effects of the treatment become specific to some undesirably limited set of conditions.

"Practical" generalizability asks the question: Are the majority of classroom teachers likely to accept the recommendations for classroom practice which are based upon the research results? Within the present study an attempt is made to increase "practical" generalizability by manipulating practical classroom variables, solving immediate classroom problems, requiring teachers to make only minor changes in their classroom practices, and supporting or contrasting statistical results with teacher opinions.

Generalizability in the present study is used in a manner which combines the Campbell and Stanley definition with that of "practical" generalizability. Attention is given to the interactions involving research design factors and the treatment as well as to the practicality of the content of the study. "Practical" generalizability is considered important for any series of studies, such as on PI, which stop short of considering practical classroom applications. "Practical" generalizability is not necessary for all educational research results but should not be ignored when attempts are made to influence classroom practices. Support for this position is given by Glaser and Ebel below.

Glaser (1969:161) points out that "behavioral scientists are likely to meet with the least opposition in producing educational reforms if they concentrate on the development of instructional equipment and materials which do not require major changes in the habit structure of teachers." The implication is that educational research

of the type which wishes to directly and immediately affect classroom practices should be designed to provide a greater possibility for "practical" generalizability of results.

Because research on PI has progressed to the point where applications of PI to the classroom have been experimentally recommended (see Chapter II), perhaps more research consideration should be given to influencing teachers to accept PI into their classrooms. For example, Ebel (1969) suggests that teachers want immediate solutions to classroom problems, and that the best way of providing these solutions at the present is through questionnaires. There are two dimensions to Ebel's proposal which may relate to "practical" generalizability. First, "practical" generalizability may be increased (for any type of research results) by concentrating on immediate classroom problems. Second, it may be that teachers are less suspicious of questionnaire data and teacher testimonials than of unfamiliar reports of statistical results. For the latter reason (and others) teacher questionnaires are an important part of the present study.[1]

The immediate problem attended to in the present study is the achievement level in high school chemistry. Chemistry is a subject which requires a sound basic knowledge of what has come before if new facts and principles are to be learned effectively. Teachers have often recognized this requirement by providing drill and problem-solving activities. Such practices are supported by learning theories which contend that retention and transfer are a function of overlearning.

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1. Other aspects of the present study which provide for increasing the "practical" generalizability of results are discussed in Chapters II and V.

Advocates of PI suggest that the characteristics of PI (see Chapter II) are well suited to the task of assisting the classroom teacher in the above respect.

The relationship of PI to chemistry instruction and to the CHEM Study course in particular is discussed in greater detail in the latter part of Chapter II and in Chapter V.

Statement of the Problem

The problem in this study is to determine what differences in student achievement, student attitude, and teacher opinion exist between teacher directed and nondirected approaches to using PI adjunctively to CI for preview and review in high school chemistry.

Definition of the Terms

Adjunctive PI - programmed instruction which is supplementary to the core conventional-instruction techniques

CI - conventional instruction

Conventional instruction (CI) - instruction in a self-contained classroom not involved in team teaching, independent study or any other nontypical program; includes the experienced teacher's conventional emphasis on lectures, discussions, demonstrations, laboratory work, homework, and audio-visual aids. (When the term CI is used differently, as is the case in Chapter II, it is defined in context.)

Directed - an independent variable in the present study. The teacher provides guidance and assistance in the use of the PSs

(Programmed Supplements) by the students. The PSs would take an active part in the classroom instruction without interfering substantially with the teacher's regular practices. A directed teacher approach would include, at a moderate level, some of the following activities:

1. examining individual difficulties encountered in the PSs with the whole class on suggestions from students.

2. helping students individually (at their desks) with difficulties encountered in the PSs.

3. urging the students to pay particular attention to a series of frames in the PSs.

4. general references to the PSs during the conventional instruction with regard to broad subject matter topics.

5. specific references to the PSs regarding specific problems encountered during the regular lesson (may include stopping a lecture or discussion to turn to the PSs).

6. general and specific teacher initiated inquiries regarding the students' understanding and actual use of the PSs.

Frame - a single unit of information or a single statement in a program which requires the student to respond to it.

Horizontal programming - a program format in a programmed text in which the page must be turned after writing a response in order to verify the response and to read the next frame.

Independent variables - see directed, nondirected, preview and review.

Integrated PI - any combination of PI (programmed instruction) with some other form of instruction; one such combination is

adjunctive PI.

Knowledge of results (KR) - believed to be a method of reinforcement which leads to increased learning. The process involves providing the correct response to the student after he has made his response to a frame of a program.

KR - knowledge of results.

Linear program - especially devised to advance the student step by step to his learning goal, and so organized that the student will make a minimal number of errors; a nonbranching program which usually involves constructed responses.

Nondirected - an independent variable in the present study. The teacher makes a conscious effort to provide as little guidance and assistance with the PSs as would be consistent with good teaching. The teacher would not ignore student questions from the PSs but before answering would refer the student to previous frames in the PSs, to the CHEM Study textbook, and/or to the student's notebook. These, and the following, practices are not only consistent with good teaching and necessary for "practical" generalizability of results, but are necessary to avoid student alienation towards the PSs. Any teacher direction would be limited to the following:

1. directing the students to complete the relevant chapter(s) in the PSs and to hand the PSs and the completed assignment to the teacher on a specific day.

2. passive supervision of the classroom use of the PSs without any teacher initiated activities specific to the PSs. The teacher

would probably supervise from the front of the classroom and would not walk around the classroom for purposes of initiating and/or answering individual student questions.

PI - programmed instruction.

Preview - an independent variable in the present study; an antecedent position in the total instructional sequence of each chapter. The relevant assignment from the PSs would be completed in the time between the first and the middle lesson for a particular chapter. The PSs and the assignments would be turned in to the teacher during the middle lesson.

Programmed instruction - a method of instruction using a sequence of carefully planned subject-matter items which are presented to the learner so as to require his active response.

Programmed Supplements (PSs) - the horizontally programmed programmed-text Programmed Supplements in General Chemistry, Volume I, by G. M. Borrow et al. (New York: W. A. Benjamin, Inc., 1964).

PSs - Programmed Supplements.

Response mode - the manner in which the student is required to respond to a frame in PI; may be categorized as overt or covert, and constructed or selected from multiple-choice alternatives.

Review - an independent variable in the present study; a position late in the total instructional sequence of each chapter. The relevant assignment from the PSs would be completed in the time between the middle and the last lesson for a particular chapter in the course. The PSs and the assignment would be turned in on the day of or the day before the chapter exam.

Step size - "The amount of increase in subject matter difficulty with each step of the program. A large step size could result in relatively few frames (per subject-matter unit) while a small step would be indicated by a relatively large number of frames in the program." (Cook, 1961:153).

Vertical programming - a program format in a programmed text in which the next frame and the correct response for the current frame are on the same page as the current frame. The correct response and the next frame are usually covered by a card manipulated by the student. (See horizontal programming).

Major Hypothesis and Associated Questions

Hypothesis: There is no significant difference in achievement between teacher directed and nondirected approaches to using programmed supplements for preview and review when ability is used as a covariate, and there is no interaction effect.

Question 1: As measured by the total student responses to the student attitude instrument administered, what are the student reactions to the PSs in general and to how the PSs are used in the study? (The differences between various groups of interest were tested by the chi square statistic where appropriate).

Question 2: As indicated by free responses on initial and final teacher questionnaires, what are the teachers' opinions on adjunctive PI in general and on the optimal use of adjunctive PI in the conventional chemistry classroom?

Design of the Study

The present study seeks to compare the achievement of intact high school chemistry classes with respect to differential employment of PI adjunctively to CI. A 2 x 2 factorial analysis of covariance design in which the independent variables were the timing of the adjunctive PI presentation (preview versus review) and the amount of teacher direction (directed versus nondirected) was employed with three teachers and twelve CHEM Study 20 classes.

Five _PSs_ chapters supplemented three of the five CHEM Study 20 chapters. Two chapter achievement tests were administered as criterion measures, and Form 3A SCAT scores served as the covariate. Two student attitude measures and two teacher questionnaires provide the remainder of the research data.

A more complete discussion of the experimental design appears in Chapter III.

Delimitations of the Study

The delimitations of the study may be listed in two separate categories. First, the delimitations on the design, the treatment and the procedures due to the availability of only three class sets of _PSs_ were:

1. It was possible for only three teachers to simultaneously employ one class set of _PSs_ each. This restricted the number and kind of treatments and thus the design of the experiment. For example, the teachers could employ one class set of _PSs_ with two classes in the same semester if one class used the _PSs_ as preview and the other as

review. Three times of presentation of the PSs or comparisons of the adjunctive PI to CI were not possible with the limited number PSs and the limited time available.

2. The subject-matter content of the PSs limited their application to adjuncts of Chapters 13, 15 and 16 of the CHEM Study textbook. The application of PI was therefore restricted to Chemistry 20. The PSs did not contain any programmed materials which could supplement Chapters 14 and 17 of the Chemistry 20 course.

3. The subject-matter content of the PSs did not cover all of the chemistry concepts in any one CHEM Study chapter. As a result some concepts were supplemented while others were not, even though the achievement test covered all of the concepts of each CHEM Study chapter.

4. The subject-matter content of the PSs required a level of programming called "conceptual learning" by Klaus (1961:132). The application of the mole concept to a chemical reaction and the concept of Lewis Diagrams requires a higher level of learning than the learning of molecular formulae and molecular weights. Generalization of results should be restricted to "conceptual learning" from PI.

5. The PSs contained horizontal programs of the linear type which required constructed responses. Any generalization made from the results must therefore be restricted to similar programs.

A second set of delimitations are a consequence of the attempt to obtain increased "practical" generalizability of results:

1. The PSs were used adjunctively to CI and an attempt was made to select treatment variables which were practical and would

perhaps be acceptable to classroom teachers. PI may be applied in the classroom in a variety of ways, but in the present study the selection of the application was restricted to those applications which had a greater chance of being accepted by the majority of classroom teachers.

2. The CHEM Study version of Chemistry 20 was used in the present study because of the widespread adoption of this version for high school chemistry instruction. Generalizability may be increased by restricting the application of adjunctive PI to CHEM Study 20, but generalizability of results must consequently be restricted to CHEM Study courses.

3. The students were asked to make overt (written) responses to the programmed frames in order to provide evidence for the completion of the assignment. This is much like the requirement for any type of assignment in the conventional classroom and increases the generalizability of the results to the conventional classroom.

These delimitations will be discussed in greater detail in Chapters II, III and V.

Limitations

The limitations placed on the acceptability of the results from the present study are based largely on the difficulties encountered in any classroom research. Because of the size of the study the researcher could not observe what actually occurred in the classroom, nor would he have liked his presence to interfere in any way with regular practices. As a result one teacher's interpretation of "directed" may have been somewhat different from another teacher's

interpretation. Variations in the teachers' attitudes towards assignments may also have affected the results but the fact that all teachers were involved in all treatments should control these variations. In order to estimate these variations the teachers were asked to record the completion of assignments and the classroom time spent using the PSs.

The effects of a janitors' strike and a high experimental mortality[2] are other possible limitations. Statistical tests to estimate the effect of both of these possible limitations will be reported in Chapter IV.

Limitations on the interpretation of some statistical tests such as the possible effects of treatment groups of unequal size on attitude comparisons, and the possible effects of the analysis of covariance assumptions are discussed in Chapter IV.

A possible example of a limitation on the treatment which may decrease the chance of obtaining a significant difference is the use of a compressed semester. Because the compressed semester cuts the number of homework nights in half and because the adjunctive use of PI as employed in the present study requires homework, the compressed semester may not allow the treatments to take full effect.[3]

Significance of the Study

The present study has attempted to identify the optimal method

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2. Due to missing one or more of the two chapter exams, dropping out, or not having a SCAT score listed at the Department of Education.

3. For a more complete discussion of this factor see Chapter V.

for using PI as an adjunct to CI within the limits defined by the preview-review and the directed-nondirected dimensions. This study goes beyond the CI plus PI-versus-CI studies which have been conducted[4] by accepting that adjunctive PI increases achievement. The study attempts to build a foundation for studies in which CI itself may be changed when CI is integrated with adjunctive PI.

Plan of the Study

The present chapter has attempted to define and delimit the problem in terms of the history of PI research, the resources available, and the focus of the experimenter.

Chapter II reviews the literature in a series of categories which progressively approach the design of the present study. Emphasis is given to identifying the potential impact of intervening variables which must be controlled in the present study. The comments on the literature attempt to put the problem into greater perspective and to delimit the problem so that the experimental design will be clarified.

Chapter III describes the sample, the materials, the procedures, and the statistical design of the study.

Chapter IV reports the analyses of the results from the major hypothesis, and from the student attitude survey and the teacher questionnaires.

The final chapter presents conclusions and recommendations which are a direct result of the present study.

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4. See Chapter II, CI Plus PI-Versus-CI Studies.

CHAPTER II

REVIEW OF THE RELATED LITERATURE

Introduction

The related literature is divided into six categories, including separately the review and some comments, which progressively delimit the PI (programmed instruction) research to the problem of the current study.

PI-Versus-PI Studies

The general characteristics of PI from which the specific PI research variables have been derived include:

1. Active response by the student to carefully sequenced instructional materials.
2. The provision for immediate knowledge of results (KR), whereby the learner can judge whether his response is correct or incorrect.
3. Self-pacing, whereby the student is able to move at his own rate through the instructional program. (Popham, 1970: 112).

Both presentation and response programming variables have been thoroughly researched. Among these variables are the following which are most specific to the current study.

1. Knowledge of correct response. Schramm (1964) reported most studies found that providing students with immediate knowledge of

results (KR) at frequent intervals enhances learning. Nonsignificant differences in achievement between KR and no-KR groups have been reported in studies where the material was quite easy (as measured by error rate), thus suggesting that KR is more important in a program in which the probability of making wrong responses is high. Explanatory feedback beyond KR has been found to produce greater achievement than KR alone. Research on explanatory feedback has been largely restricted to written explanations, however, and has not been extended to teacher explanations (as was done in the current study).

2. Response mode. Both Schramm (1964) and Briggs and Angell (1964) report that the majority of studies on overt-versus-covert responses found no significant differences in achievement between response modes. This generalization however is confounded by differences in the complexity or difficulty (as measured by time to learn and number of errors) of the subject matter. Briggs (1967) cites a study by Goldbeck and Campbell where three response modes--overt (written) responses, covert (mental) responses, and reading only--were compared at three difficulty levels. The overt-response group showed significantly inferior achievement at the lowest difficulty level but showed significantly superior achievement to the covert-response group at the medium difficulty level.

Besides the overt-covert dimension for response mode achievement has also been compared between students who wrote out their responses during learning and students who selected their response from multiple-choice alternatives. Generally no significant difference in achievement between groups was found, although typically the multiple-

choice response groups took less time to complete the PI. An interaction between response mode and type of criterion test questions has been suggested and should be considered in any study. (Briggs, 1967). For example in the current study students using constructed-response PI might not perform as well on a multiple-choice exam as on a constructed-response exam.

3. Hardware versus software. Teaching machine-versus-programmed text study results have been inconclusive and current trends suggest that linear teaching machines are out. If teaching machines are to be used in the future they will probably have to be justified empirically by increased achievement through the use of multiple-choice branched programs. Presently this difference in achievement does not exist and therefore the substantial difference in cost favours the programmed text. Until the time when teaching machines can justify their cost, they shall remain, in the words of Popham (1970:112), "glorified page-turners."

4. Pacing. Schramm (1964:11) in reviewing self-pacing versus externally controlled pacing notes that, although it seems learning should be enhanced by allowing students to proceed at their own pace, "the experimental literature has not been able to demonstrate as much advantage for individual pacing as might be expected." However, the studies cited compared self-pacing with group-pacing at the average rate best for all students. When the rate of the group-pacing was varied and comparisons of achievement made between fast and slow students, it has been found that significant differences exist. (Briggs, 1967:126). The fast students do equally well under

self-paced and fast, fixed-paced presentations, but, when the fixed-paced presentation was slow, the fast students were inferior to fast, self-paced students and to slow, slow-paced students in terms of achievement. The performance of the slow students was "much better" under the slow fixed-pace than under the fast fixed-pace presentation of programmed materials.

5. Step size.[1] When significant differences in achievement have been found they usually have been in favour of programs with relatively small step size, supporting Skinner's preference for linear errorless programs. However the lack of a common definition for step size makes any generalization questionable at this point. (Briggs, 1967:127).

As is the case following the review of each category of studies an attempt is now being made to relate the above studies to the present study.

The present study controlled the variables discussed above by limiting the PI to the use of a specific programmed text.[2] The programmed text was horizontally programmed in that KR was obtained by turning a page (see definition of horizontal program). The programmed

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1. "The amount of increase in subject matter difficulty with each step of the program. A large step size could result in relatively few frames (per content unit) while a small step would indicate a relatively large number of frames in the program." (Cook, 1961: 153).

2. A more thorough description of the programmed text used is given in Chapter 3.

material becomes progressively more difficult (as indicated by the number of errors and by the number of variables, relationships, or concepts manipulated), and therefore as suggested by the research above KR probably becomes more important, particularly for the lower ability students. Additional feedback beyond KR was provided to one-half of the treatment groups by extra teacher direction.

An overt (written) constructed-response mode was employed on the present study to conform to the programmed text format and to allow for greater generalizability. The written responses were taken as evidence of completion of the assignment in the programmed text, as would probably be the case in a regular classroom. While the interaction of constructed-response PI and multiple-choice tests in the present study might have reduced the absolute achievement scores it probably did not affect the relative scores of the treatment groups.

The use of a programmed text rather than a teaching machine was essential to the present study since the treatment required the students be able to complete their PI assignment as homework. This cannot be considered as a limitation on the treatment when the above hardware-versus-software research and the cost of teaching machines are considered.

The pacing was partially controlled by the setting of a deadline for the completion of the assignment (see definitions of preview and review). If the student gave himself enough time to complete the assignment then he would be essentially self paced. However, if a student for example had to complete the assignment just before class at a rate beyond his ability, then his pacing became

externally controlled. Both of these situations impart practical generalizability to the study since both should be expected in any practical application of PI as an adjunct to CI.

The step size was set by the programmed text selected for the present study. The programs were not errorless in the Skinnerian sense. Skinner (1954) advocates linear programs with the step size sufficiently small that students will not make any errors when responding to the PI frames. However, Skinner (1969) envisioned PI as standing alone, which was not the case in the present study where PI was used adjunctively with varying degrees of teacher direction.

Both students and teachers were asked in the present study to rate the step size (see Chapter IV, Results of the Study).

The next category of studies compares PI with CI. The utility of the review relates to comparing supposedly optional PI as indicated by the studies above to CI (conventional instruction) in order to establish the relative effectiveness of the two methods.

PI-Versus-CI Studies

Reviews by Schramm (1964), Briggs and Angell (1964), and others have generally concluded that nonsignificant differences in achievement for PI-versus-CI studies are more common than significant differences. Where significant differences have been found, they have usually favoured PI. Recent criticism of these significant differences, however, has pointed out that the programmer has usually constructed the criterion tests and wording and content biases have been found which favour the PI groups. In addition, such criterion tests do not

measure all of the important goals of instruction, the Hawthorne and novelty effects are hard to estimate, and the programming variables and the definition of CI vary from one study to the next.

With these reservations on generalizations in mind, it can be noted that Schramm reported that seventeen of the thirty-six comparisons reviewed showed a significant superiority for the PI students over the CI students. Eighteen of the thirty-six comparisons of PI with CI revealed nonsignificant differences, and only one study showed a final superiority for CI.

Studies cited by Briggs (1967) illustrate the variability of CI from one study to the next. Briggs mentions studies by Roe and by Molstad where CI varied from use of textual material only, and use of a programmed lecture where the programmed materials were read to the students, to use of films as CI. This type of difficulty arises for most gross comparison studies where CI is used as a standard when it has not been adequately defined and standardized itself.

Besides the above comments which were directly related to the studies reviewed, the comments below should serve to illustrate the significance of the above studies to the present study.

Perhaps the most important contribution PI-versus-CI studies have made to the knowledge of how to apply PI is the conclusion that students do in fact learn from PI. If interpreted in this narrow sense the next question to be answered relates to the role that PI should take in the classroom. However, having proven that students learn from PI many pedagogists have interpreted the PI-versus-CI

research as justification for using PI exclusively as a method of instruction. As mentioned earlier (see Background of the Problem) any attempt at providing a major role change for a large number of teachers is not likely to meet with success. As a result nonexperimental applications of PI alone to the classroom were and are minimal.

Other difficulties for PI-alone applications are the lack of programmed materials which teach a complete range of subject matter, the problem of what to do with students who finish before the rest, and the student boredom which usually accompanies extended use of PI alone.

The present study has attempted to minimize the latter two difficulties respectively by using PI in an adjunctive fashion to CI where the PI assignment was completed as homework, and where the PI was a supplementary part of the total amount of instruction given.

Before proceeding to discuss the application of PI adjunctively to CI a brief inspection of a few studies, in which PI was used as the core or main presenter of subject material, has been undertaken. The review of these studies should serve to distinguish between integrated PI and adjunctive PI, to illustrate that PI and CI can work together towards a mutual goal, and to point out the difficulties of applying PI as the main method of instruction.

PI Plus CI-Versus-PI or CI Studies

Ryan (1968) reports that teacher involvement in PI can enhance student learning. When he compared the achievement of two fourth grade social studies classes, Ryan found a significant difference ($p < 0.05$)

favouring PI plus teacher involvement over PI where the teacher merely supervised. Teacher involvement activities included reading each frame minus the response word to the students, allowing the students to write their response, randomly calling on students to supply the response orally, and then rereading the frame to the students with the correct response included. No explanation of why a response was correct or incorrect was given to the students. The programmed materials were not supplemented by other materials nor were explanations given as is the case in some studies discussed below.

Ryan also found that when grouping students together some information regarding the amount of learning from PI was lost. "For instance, although the high reader but not the low reader was learning in the PI-alone group, both the high and low readers were helped in achieving when a teacher or teacher aide was included in the instructional process." (Ryan, 1968:53).

The Draper Project (McKee, 1968) and the Concept of the Directed Program (Ellert, 1968) are two more examples of PI used as the core of a learning system, for teaching reading, language and arithmetic to prisoners and for teaching German language to university students, respectively. Experience led the teachers to conclude that PI must be supplemented to be effective. Both competition and support of another human being were cited as being necessary supplements to PI. "The test results for the teacher-directed class indicate that these students were learning more deeply and intensively, as well as more enthusiastically." (Ellert, 1968:3).

Park (1968) reports no significant difference in achievement

between groups which received one hour of classroom instruction to supplement individual use of a programmed text in a junior college pre-transfer English composition class, and groups which received no classroom instruction to supplement the PI.

Hatch and Flint as reported by Schramm (1964) compared three groups of junior college students. Group 1 received three hours of PI in basic electronics and three hours of CI each week; Group 2 received three hours of PI; Group 3, three hours of CI. The PI-versus-CI test results were nonsignificant, but both the PI plus CI-versus-PI and PI plus CI-versus-CI comparisons showed significant differences in achievement favouring the integration of PI and CI.

In this study the obvious difference in instruction time (six hours versus three hours) may be objectionable but is not misleading if the conclusions drawn are that PI and CI can be mutually facilitating, and that extra time spent independently working on PI can increase learning significantly. Both of these conclusions are important to the justification of the present study.

When PI was supplemented by interim testing and compared to PI alone a significant difference ($p < 0.01$) was found by Shell (1970) on both a post-test and a retension test on achievement. The subjects were teachers-in-training taking a general science course.

The foregoing studies are important to the current study in that they illustrate that PI and CI can be integrated effectively, and together may produce greater learning gains than either by itself.

However the limitation placed on the teacher's role-change within the present study (see Background to the Problem) would disallow the use of PI as the core instructional method. In addition sufficient well-written PI does not exist to constitute the core of a high school chemistry course in Alberta. Much of the better PI available has been written to supplement CI not replace it, and therefore would not suffice for PI core material.

The next two categories of studies reviewed employ PI as an adjunct or supplement to CI in comparisons with PI alone and with CI alone.

CI Plus PI-Versus-PI Studies

Only two studies in this category were found in the search through the literature. Cited above was a study by Hatch and Flint in which three hours of CI plus three hours of PI per week was reported to produce significantly greater achievement than three hours of PI per week.

In a similar study Klaus (1961) gave PI a smaller supplementary role to CI. The CI included daily television lectures on high school physics, use of a textbook, and physics laboratory exercises. No significant difference in physics achievement between the adjunctive PI group and the PI-alone group was found.

The present study is more concerned with how CI plus PI compares to CI rather than to PI since CI is a more known standard (within the restrictions mentioned earlier), and since CI plus PI must replace CI

alone if it is to be accepted in the conventional classroom. To put the above studies in proper perspective they are discussed in combination with the next category of studies.

The following category of studies is probably the most directly related group of studies to the present study in that no studies were found in the search of the literature which paralleled the present study's design.

CI Plus PI-Versus-CI Studies

Both the Hatch and Flint and the Klaus studies were extended to compare CI plus PI to CI and both found a significant difference in achievement favouring the adjunctive PI groups. The Klaus study results are particularly important because of time equalization and because the PI constituted a small part of the total instruction. (These two aspects of the Hatch and Flint study were criticized above.)

Goldbeck and Briggs (1962) also found that the CI plus PI groups performed significantly better on achievement tests on government (a high school course) than did the CI-alone groups. In this study lecture discussions constituted three-quarters of the instructional time and were used to introduce and follow-up the PI for both high and low ability high school students. The same programs used under the same conditions were effective for both high and low ability groups. In all cases (over all ability levels, teachers, and segments of the course) the integrated instruction performed better than did the CI alone. In commenting on their results Goldbeck and Briggs (1962:22) state that "this finding was especially striking

because only a small portion of the class time was devoted to programmed learning."

Also discussed by Goldbeck and Briggs is the rationale behind using PI as an adjunct to CI. For example, they suggest that repetition between methods (i.e. repeating instruction on a subject-matter topic by both CI and PI) is probably more effective than repetition within methods. The inference here is that PI as an adjunct to CI may be used to provide drill and repetition of facts and concepts presented by CI. In many studies the repetition-versus-initial instruction factor is not stated explicitly, nor is whether the CI or the PI is used as preview or review to the other (see definitions of preview and review as employed in the present study). The PI in the present study largely repeated the CI subject matter (see discussion of materials, Chapter 3).

It is suggested by Goldbeck and Briggs that PI provides an unambiguous homework assignment. They recommend a start at the PI homework assignment during class time to increase the chances of having the homework completed. (This was done in the present study). Like the proposal for interim testing to accompany PI mentioned earlier, this homework recommendation makes good pedagogical sense regardless of the method of instruction employed.

Benson (1968) utilized linear PI as an adjunct to class demonstrations in seventh grade industrial arts and uncovered significant differences ($p < 0.01$) on a technical knowledge variable and on an assistance required to complete the job variable. The significant differences favoured the treatment groups which had

received PI to assist in learning manipulative operations (perhaps analogous to lab work in science). No significant differences were found on a time required to complete the job variable, on a quality of the completed job variable, or on a CI plus PI-versus-CI plus PI comparison. The latter involved identical CI but the PI either contained illustrations or not, and was the only example of this type of research comparison found in the literature.

Dickson (1965:29) employed PI as supplementary review to the CI of two high school chemistry topics and found that review with PI was "significantly more effective than teacher review or review by pupils using their own notes." The sample size and the statistics employed make the conclusions somewhat questionable. However, Dickson was a practicing teacher, and the application of the PI adjunctively was perhaps an indication of an application acceptable to other practicing teachers.

Deeming (1966) conducted a study in which half of a freshman gross anatomy class was given a PI assignment as preview the night before the lecture which covered the same subject material. Both the high and low ability PI students (as identified by a pretest) showed significant increases in comprehension over the control group. The medium ability PI students did not increase their level of comprehension significantly compared to the medium ability CI students.

Hawker and Glaser (1966) reported on the individualized use of PI as a review tool in fifth-grade mathematics. They compared PI review with teacher review and with workbook review, and found that the Program Group performed significantly ($p < 0.01$) higher than the two

other groups on a final test. Also to be considered is the time to complete the review, since the Program Group took one-half the time (on the average) to complete the review and yet did significantly better on the achievement test.

Before looking at the nonexperimental literature related to adjunctive use of PI an attempt is made to relate the above studies to the present study.

Of the nine studies reported above in which CI and PI were integrated (with PI taking the adjunctive role) eight reported statistically significant differences favouring CI plus adjunctive PI over CI or PI alone. These findings become particularly important to the present study when combined with the requirement for a minor role change for teachers in order to facilitate "practical" generalizability of any outcomes of the present study (see Background of the Problem). As well as being experimentally recommended these studies represent the type of PI applications which might be acceptable to a large number of practicing teachers.

Caution is required when grouping these studies together as if they were reproductions of each other. In the studies reviewed the type and amount of both the CI and the PI varied from one study to the next and were not always specified clearly. This may detract somewhat from the reproducible reliability of the results but adds to the validity of the results by indicating that PI can be used effectively in a variety of adjunctive situations.

Accepting the fact that students do learn from PI, and

accepting the trend indicated by the above seven adjunctive-PI integration studies, the current study has attempted to discover if the manner in which the PI is employed makes any difference to chemistry achievement in high school. By manipulating a number of independent variables related to the adjunctive use of PI the experimental results may indicate an optimal approach in terms of achievement, or may indicate that any approach (within the limits defined) is acceptable. Other intervening CI and PI variables must, of course, be controlled and described to provide both internal and external validity, respectively.

Speculative Literature on Adjunctive PI

In addition to the authors of the research reviewed above other authors have advocated using PI adjunctively to CI. Most of these authors go beyond integration for the sake of increased achievement of present goals and suggest that with adjunctive PI the CI can be altered to facilitate the achievement of new or presently ignored goals. Such considerations are beyond the scope of the present study but are useful in putting the present problem into perspective and for suggestions relative to recommendations for further research (see which).

Popham (1970:114) for instance suggests that "instead of having to provide some students with 'busy work' while he deals with others, the teacher can give the first group programmed materials that can be relied upon to teach worthwhile things." Also PI can "relieve the teacher from some of the more time-consuming tasks that programmed

materials can as readily accomplish."

Ramsey and Howe (1969) recommend PI for only part of the total learning picture, such as transmission of specific content and review of principles. Ausubel (1968:263) speculates that

> teachers have more time to devote to these latter objectives (acquisition of independent and critical thinking ability), to cultivate a questioning attitude toward established knowledge, and to focus on the discovery aspects of acquiring new knowledge, if the more stable and substantive aspects of a discipline are learned individually by means of PI.

Shimabukuro (1964:277) advances the hypothesis that "there are characteristics and weaknesses inherent in PI which require the knowledge and skills of the trained classroom teacher." The problems mentioned are motivation, maintaining interest, and enrichment of the program content. An example given for the latter is experiments to supplement chemistry and physics.

The rest of the speculative literature reviewed below was written in an attempt to influence chemistry teaching at the high school and college level. For instance, Sayles (1966:40) feels that programmed chemistry materials can be used to an advantage in the form of an out-of-class self-study aid "allowing more class time in which the teacher may give more detailed attention to developing an understanding of the material."

Besler (1966:159) contends that "programmed instruction should be used in teaching CHEMS, ... using programs as supplements rather than substitutes for lecture, text, etc." In discussing PI in Chemistry as preview or review Day (1963:14) proposes that "programs can be used either to introduce the subject, or to supplement or replace

the textbook on that subject." Young (1961:465) suggests the adjunctive-preview approach where the programs are completed before class in order that "a chemistry teacher can treat these same topics more fully in his lectures, or he can use the now available class time for a discussion of new topics which should be added to the curriculum."

Bakker (1963) recommends a variety of PI applications including 1) precourse review to equalize student backgrounds, 2) simple initial instruction, 3) advanced instruction, and 4) pre-lab, lab, and post-lab instruction. Leahy and Siegel (1962:45) when discussing the relationship between the science laboratory and PI take a different view than Bakker. For them PI will not enter the laboratory activities directly, but when used otherwise may "release both the student and the teacher for more laboratory work."

Powell (1963:24), an author of some widely distributed commercial chemistry programs, designed programs "to give practice (or drill) in a sufficient number of problems so that the students were sure of the method and principle." PI "is a supplement to the live teacher and cannot substitute for him. Most students of high school age need human contact in the educational process." Uses suggested by Powell are for review, for testing, for remedial work, for homework, and for introducing new material.

In terms of the present study the remarks of Powell seem to have greater potential pedagogical and research value than the proposals of the other authors. Difficulties in changing classroom practices and in conducting accurate research often arise from taking too many steps

at once (see below).

The pedagogical difficulty was discussed earlier in Background of the Problem, and relates to the problem of having teachers accept a major role change. The probability of having a large number of teachers accept PI as an adjunct to CI plus asking them to change their emphasis on various goals in their conventional instruction is probably less than the probability of teachers accepting only the adjunctive PI into their classrooms. It may be that teachers will automatically change the emphasis of their personal instruction to different goals, but external pressure to do so is not likely to meet with success until adjunctive PI has been accepted.

The research difficulty mentioned relates to the problem of simultaneously changing two variables, neither of which has been investigated before. The research design would have to be expanded well beyond that of the present study in order to produce adequate controls. If the design was not expanded, assumptions about the optimal adjunctive use of PI would have to be made. One purpose of the present study is to partially remove the necessity for such an assumption. In this way the present study goes beyond what has been researched before and at the same time lays a partial foundation for future research.

In the present study PI was used adjunctively to CI in a variety of ways. The CI was not altered substantially other than giving up some classroom time to PI. The variables manipulated in the 2 x 2 design were the timing of the adjunctive PI presentation (preview versus review) and the amount of teacher direction (directed versus

nondirected). The details of the experimental design will be set out in the next chapter.

CHAPTER III

EXPERIMENTAL DESIGN

Population

The population for the study from which the sample was drawn consists of Chemistry 20 classes on a compressed semester using Chapters 13 through 17 from the CHEM Study textbook in the conventional classroom.

Sample

To be part of the sample the CHEM Study 20 classes had to be those of an experienced chemistry teacher who was scheduled to teach four such classes, preferably two classes per quarter (compressed) semester. The requirement was necessitated by the research design (see below) and severely restricted the selection of teachers and classes.

Three experienced teachers who met the requirements were located--two from a large Edmonton Public composite high school and one from a somewhat smaller Edmonton Separate composite high school.[1] The two teachers from the Edmonton Public high school taught all of the students (eight classes) enrolled in Chemistry 20 for the first two quarter-semesters in that school. Therefore all of the students registered in Chemistry 20 for these two quarter-semesters in that

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1. The two schools were Jasper Place Composite High School and St. Joseph's Composite High School, respectively.

school were in the experimental sample. The third teacher who taught in the Edmonton Separate school did not teach all of the Chemistry 20 classes in that school.

Classes were randomly assigned to treatments within the limits defined by the experimental design (see below). For example, a class in the first quarter-semester could be assigned to either of the two treatments employed by his teacher in that semester. Students could not be randomly assigned to classes and therefore intact classrooms were used as the basis of assignment to the treatments.

No teacher approached turned down the request to participate in the study. The participating teachers were not selected because of their knowledge of or partiality toward PI. Each teacher held at least one university degree. Initially the teachers were cooperative but skeptical, as might be expected of most experienced teachers.

A statistical description of the sample is presented in Chapter IV.

Design

Since there were two teacher approaches (directed and nondirected) and two PI presentation times (preview and review), the study involved a 2 x 2 factorial design. Because students were not randomly assigned to classes, a statistical control was employed in the analysis of the data by means of two-way analysis of covariance. The major null hypothesis concerning differences in achievement between treatment groups was tested using the chapter test scores separately as the criterion. The single covariate was Form 3A SCAT scores.

To control for the teacher variable and sources of internal invalidity[2] each teacher used the PSs adjunctively to their CI in all four ways. The experimental arrangement may be summarized as follows:

Quarter-Semester	Teacher 1
1	Preview-nondirected and Review-nondirected
2	Preview-directed and Review-directed
	Teacher 2
1	Preview-directed and Review-directed
2	Preview-nondirected and Review-nondirected
	Teacher 3
1	Review-nondirected
2	Preview-directed and Review-directed
3	Preview-nondirected

Procedure

The procedure related to the specific treatments is best outlined by the definitions of the independent variables given in Chapter I. The detailed treatment and data collection procedures are contained in Appendix H, Instructions for Teachers.[3] The sequence of activities was as follows:

1. hand out and read the Instructions for Students (see Appendix G).

2. use Chapters 2 and 3 of the PSs adjunctively to Chapter 13 of the CHEM Study textbook.

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2. See Campbell and Stanley (1966:5-6).

3. Instructions for Teachers also contains information related to the specific content covered in the PSs.

3. administer the student attitude measurement device.

4. do not use the PSs with Chapter 14.

5. use Chapter 4 of the PSs adjunctively to Chapter 15 of the CHEM Study textbook.

6. administer the Chapter 15 achievement test as a criterion measure.

7. use Chapters 5 and 6 of the PSs adjunctively to Chapter 16 of the CHEM Study textbook.

8. administer the Chapter 16 achievement test as a criterion measure.

9. administer the student attitude measurement device for a second time.

The covariate measure was obtained by searching the Department of Education cumulative record cards for the Grade IX Form 3A SCAT scores of the students involved.

Materials

The PSs were selected from among programmed materials published on chemistry topics on the basis of being the most satisfactory of the materials inspected by the researcher. The researcher had used the PSs in his own chemistry classrooms for several years. The subject matter covered by the PSs involved higher level concepts than the calculation of molecular weights, writing of molecular formulae, naming of compounds and the balancing of chemical equations typical of the programmed materials commercially available.

As described in the Instructions for Teachers (see Appendix H) five chapters from the PSs were used adjunctively to three CHEM Study chapters. For purposes of obtaining criterion measures of achievement only Chapters 15 and 16 of the CHEM Study textbook were involved. Both of these chapters are primarily qualitative in nature. Energy levels, atomic orbitals, electronic configurations, and ionization energy are presented in Chapter 15, while covalent bonds, bonding capacity, hybridization, ionic bonds, shapes of molecules, electric dipoles, and double bonds are considered in Chapter 16.

Chapter 4 of the PSs has some terminological differences with the CHEM Study Chapter 15 such as the use of the terms "azimuthal quantum number" and "magnetic quantum number" and their respective numerical values rather than the letter designations for subshell and orbital descriptions used in the CHEM Study textbook.

Chapters 5 and 6 in the PSs are titled "Lewis Diagrams of Atoms and Molecules" and "Structure of Molecules: Orbital Diagrams" and provide a horizontal extension of material in CHEM Study Chapter 16. The terminological differences with Chapter 16 are not as great as in the Chapter 15 case noted above. The primary thrust of the PSs in these chapters is to provide a large number of classical examples for the students to work with.

Achievement Measures

Two achievement tests were developed as criterion measures; one 50 minute open-book test for each of Chapter 15 and 16. The tests were developed by the experimenter and were criticized by the teachers

involved for content validity and question clarity. The test questions were subsequently revised on the basis of the teachers' criticisms.

The two tests were based strictly on the CHEM Study 20 course content as outlined specifically in the textbook. Care was taken to not have the test influenced by the content or the wording in the PSs. Furthermore the content tested was representative of all of the CHEM Study chapter content and was not restricted to those topics covered by the PSs. (See Appendices B and C for copies of the tests.)

The Chapter 15 test contained twenty-five multiple-choice questions while the Chapter 16 test contained sixteen multiple-choice questions plus eighteen short-answer type questions. The scores from these tests were used as separate criterion measures for the two two-way analyses of covariance. The scores were used separately because of the differences between Chapters 15 and 16 as described above. The treatments employed may affect the criterion achievement scores differently in Chapter 15 than in Chapter 16.

The Kuder-Richardson (KR-20) estimate of internal-consistency reliability was obtained for the twenty-five item Chapter 15 achievement test and the sixteen multiple-choice items of the Chapter 16 test. The computed values were 0.54 and 0.49 respectively. The probable reliabilities of similar tests of fifty items would be 0.75 and 0.70. When the test was constructed no attempt was made to make items of equal difficulty or to make items where the proportion passing an item would be 0.50. The result of such attempts could have increased the KR-20 value. (Guilford, 1965.)

Covariate Measure

The Cooperative School and College Ability Tests (SCAT, Form 3A) scores were used as the covariate in the two way analysis of covariance. The students' Grade IX SCAT scores were obtained from the Alberta Department of Education cumulative record cards. As explained earlier the lack of a SCAT score on record with the Department of Education resulted in the student's set of data being dropped from the statistical analysis.

SCAT scores were used as the covariate because they are a measure of general ability and as a result may be employed to statistically control ability differences between treatment groups (Fowler, 1965:322). The predictive validity of the test scores over a two year period for predicting a student's ability to succeed in his school work is reportedly good. Correlations between SCAT scores and achievement are reported to be no less than 0.43 over a two year period.

The raw score total of the verbal and quantitative parts of the SCAT test was used as the covariate. The SCAT (Form 3A) test consists of two thirty-item verbal parts and two twenty-five item quantitative parts for a possible raw score total of one hundred and ten.

Student Attitude Measure

A series of fourteen statements was presented to the students

and their reaction recorded on a five-point Likert Scale ranging from strongly agree to strongly disagree. There were two general categories of statements within the instrument; one category of seven statements probed the students' reactions to the PSs in particular and to PI in general, while the other category of seven statements dealt with the ways in which the PSs were utilized in the present study.[4]

When constructing the statements for the instrument, care was taken to have both "agree" and "disagree" responses indicate a favourable reaction. Other recommendations by Oppenheim (1966) on statement writing were applied where possible.

The instrument was administered twice to each student. The initial reactions to the statements were obtained following the use of the PSs as an adjunct to Chapter 13. The final administration following the Chapter 16 achievement test preceded the return of the test results.

The students were not required to identify themselves on the instrument[5] but were asked to indicate their mark obtained in Chemistry 10. Each response sheet was identified according to the treatment group from which it came.

Teacher Experience Measures

Two teacher questionnaires were administered; the initial

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4. A copy of the instrument appears in the Appendix D.

5. Although this procedure allowed for student anonymity it caused difficulties due to absenteeism when comparing initial and final reactions.

questionnaire after the first quarter-semester and the final questionnaire after the teacher had completed the treatment with his last class. The initial questionnaire was less extensive than the final, but both attempted to obtain the teachers' experience-strengthened opinions on the optional use of the PSs (within the limits defined by the treatments) the appropriateness of the programmed text used, the reactions of the students, and the generalizability of results.

The purpose of the questionnaires was two-fold. First, the teachers' recommendations are important for purposes of indicating how classroom teachers might use PI adjunctively to CI within the limits defined by the present study. Second, the teachers might recommend that the independent variables manipulated were not perceived as being realistic or intuitively important classroom variables. Both of these recommendations are important for "practical" generalizability, whether the results indicate a significant difference or a nonsignificant difference in achievement between treatment groups.

Statistical Procedures

Where intact classrooms are employed a statistical rather than experimental method may be used to adjust for the effects of uncontrolled variables and allow for a valid evaluation of the outcomes of the experiment. (Ferguson, 1966). The statistical method used in this situation of intact classrooms in the present study is the analysis of covariance.

To calculate the F ratio to test the difference between adjusted criterion means an adjustment is made to the total and within groups

sums of squares. The resulting residual sums of squares after the regression adjustment are used in the regular analysis of variance manner to calculate the F ratio.

The adjusted total and "pooled" sums of squares for the criterion, X, may be calculated from deviation scores as follows:

$$SS = \sum\sum x^2 - \frac{(\sum\sum xy)^2}{\sum\sum y^2}$$

The adjusted criterion means for each group may be calculated as follows:

$$\bar{X}_{.j}^{*} = \bar{X}_{.j} - b\,(\bar{Y}_{.j} - \bar{Y})$$

in which $\bar{X}_{.j}^{*}$ is the adjusted criterion mean for each group, $\bar{Y}_{.j}$ is the covariate mean for each group, and b is the within-groups regression coefficient. (McNemar, 1962:371). The adjusted criterion means would indicate the differences between groups and would usually be calculated after the F test on the adjusted sums of squares had been computed.

The assumptions underlying the analysis of covariance include all of the assumption made in the usual analysis-of-variance approach. As in the usual analysis of variance the F tests in the analysis of covariance are "robust" with respect to the violation of the assumptions of normality and homogeneity of the residual variance. (Winer, 1962).

Specific to the analysis of covariance the assumptions of linearity of regression and homogeneity of regression coefficients are made. A test is made in the present study for homogeneity of regression coefficients. The significance of the gain in adjusted sums of squares (and subsequent loss in predictive power) when a "pooled" regression coefficient is assumed over individual within-cell

regression coefficients is tested for each covariate by an F test.

A description of the analysis of covariance for a factorial experiment with multiple covariates is given in Winer (1962:595-621). The present study employs a 2 x 2 factorial experiment with one covariate. The ANCV25 computer program of the Division of Educational Research Services, University of Alberta, was used for computing the results.

CHAPTER IV

RESULTS OF THE STUDY

Introduction

The report of the results of the present study is divided into three sections. The first section reports the results of the treatment effects on student achievement. The second and third sections present data gathered by the student attitude measures and the teacher questionnaires, respectively. Each section presents the results, a discussion of the results, and some speculations on the results.

Statistical results were computed by the Division of Educational Research Services documented computer programs. In the statistical analyses carried out the difference between criterion achievement scores and between observed and expected frequencies is considered to be statistically significant if the probability of observing such a difference as a result of sampling error is 0.05 or less.

The two treatment variables in the 2 x 2 design were the presentation time of the adjunctive PI (preview-review) and the amount of teacher direction (directed-nondirected), as defined in Chapter I. The 2 x 2 design involved three teachers with four classes per teacher for a total of twelve classes and 225 students. No treatment was repeated with the same students.

Treatment Effects on Achievement

Results

The Major Hypothesis was rejected on the basis that a significant

difference in achievement ($p < 0.05$) favouring the teacher-directed approach over the nondirected approach when PI was used adjunctively to CI was obtained on a two-way analysis of covariance using SCAT scores as the covariate when using the Chapter 16 test scores as the criterion measure. Table 2 shows that no significant difference in achievement on the Chapter 16 test was found on the time of presentation (preview-review) variable, nor was there a significant interaction between the two treatment variables.

No significant differences in achievement between treatments nor a significant interaction between treatments were obtained when a two-way analysis of covariance was conducted on the Chapter 15 achievement test scores. (See Table 1).

Table 3 presents the results of the homogeneity of variance tests on both the adjusted and unadjusted scores and the homogeneity of regression coefficients tests. In all cases the hypotheses of no significant difference in variance of criterion scores within cells or groups and of no significant difference in regression coefficients between treatment groups were not rejected.

The differences in the number of students per cell was a concern which was partially dissipated by the homogeneity test results mentioned above and by the persistence of the significant difference in achievement on the main effect of amount of teacher-direction when sex and teacher variables were substituted for the preview-review treatment variable in a two-way analysis of covariance. Apparently a rearrangement of the within cell observations had little effect on the direction main effect. The results for the analysis of covariance presented in Tables 7 and 8

Table 1

Two-Way Analysis of Covariance on Chapter 15 Scores for Preview-Review and Directed-Nondirected Treatment Variables

Source	SS	DF	MS	F-RATIO	P
P-R	6.38	1	6.38	0.62	0.43
D-ND	3.23	1	3.23	0.31	0.58
P-R x D-ND	1.05	1	1.05	0.10	0.75
COV	356.97	1	356.97	34.62	<0.001
ERRORS	2268.20	220	10.31		

Table 2

Two-Way Analysis of Covariance on Chapter 16 Scores for Preview-Review and Directed-Nondirected Treatment Variables

Source	SS	DF	MS	F-RATIO	P
P-R	1.36	1	1.36	0.06	0.81
D-ND	156.66	1	156.66	6.38	0.01
P-R x D-ND	13.04	1	13.04	0.53	0.47
COV	1345.58	1	1345.58	54.78	<0.001
ERRORS	5404.03	220	24.56		

Table 3

Bartlett and Box Tests for Homogeneity of Within Cell Variances and Tests for Homogeneity of Regression

Tests	Probability, Chapter 15	Probability, Chapter 16
Homogeneity of variance	0.15 0.18*	0.42 0.94*
Homogeneity of regression	0.81	0.10

* Calculated on adjusted values

Table 4

Cell Sizes, Means, and Variances for the Criterion Measures

Cell	Cell Size	Mean		Variance		Mean*		Variance*	
		Ch.15	Ch.16	Ch.15	Ch.16	Ch.15	Ch.16	Ch.15	Ch.16
P-D	70	11.2	16.8	11.5	37.0	4.68	-1.68	10.1	24.6
P-ND	44	11.2	15.4	8.0	23.4	3.76	9.56	6.9	23.2
R-D	51	10.7	16.4	11.4	29.0	4.67	6.14	10.5	26.5
R-ND	60	10.8	15.6	15.5	29.4	1.38	-0.51	13.2	22.4

* Adjusted values.

in the Appendix A indicate a sex-by-treatment interaction ($p < 0.05$) favouring female students with the directed approach and male students with the nondirected approach, and a significant sex difference ($p < 0.05$) favouring females when Chapter 15 achievement scores are used as the criterion measure. No significant interaction of sex and treatment nor a significant sex main effect was obtained when Chapter 16 achievement scores were used as the criterion measure. (Note that it was Chapter 16 which produced the significant teacher-direction main effect difference.) All other sex and teacher main effects and their respective interactions with treatments proved to be nonsignificant when either chapter test was used as the criterion measure.

Two problems which may have affected the results are experimental mortality and a janitors' strike. Experimental mortality was a result of incomplete student data when students were absent for exams, dropped the course, or did not have a SCAT score on record with the Alberta Department of Education. Analysis showed that the criterion score mean of the incomplete-data group was lower than the criterion score mean of the complete-data group. The variances of the two groups were sufficiently different to reject the hypothesis of the no significant difference in variance of criterion scores. Tests did not uncover any differential mortality between the treatment groups.

The janitors'-strike problem occurred in the school where Teacher 1 and 2 taught.[1] Because of the balanced design for these two teachers all four treatments were represented in both the strike and

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1. See the Design in Chapter III.

nonstrike situations. Another reasons to suggest that the strike did not effect the results was that the first quarter semester was extended and the second quarter-semester was shortened in an attempt to equalize the time for the strike and the nonstrike students. A two-way analysis of covariance for strike effects or strike-treatment interactions showed no significant differences in achievement.

Discussion

The finding of a significant difference in achievement favouring the teacher-directed approach when PI was used adjunctively to CI is, of course, limited in its generalizability. First there are the cautions mentioned above related to the procedural and statistical difficulties. To the best of the experimenter's knowledge no statistical assumptions have been violated but because of cell size differences some doubt about the validity of the results remains. The strike problem, like the use of the compressed semester and the small part that PI took in the total instructional sequence, was not likely to increase the chance of obtaining a significant difference in achievement between treatments. These three factors would probably tend to decrease the effect which the treatments may have had over longer periods of time, and therefore adds increased importance to the significant difference in achievement obtained. Perhaps a longer time period would produce greater differences in achievement than in the present study and might be especially important for materials like those employed in Chapter 15.

To attempt to explain why the significant difference on the teacher-direction variable was obtained on the Chapter 16 and not on the

Chapter 15 achievement test results requires an examination of the relationships among the tests, the PSs, and the CHEM Study textbook. As mentioned in Chapter III the PSs are more closely matched to the textbook material for CHEM Study Chapter 16 than for Chapter 15. Combining teacher comments with some speculations suggests that perhaps the difference in energy units--electron volts rather than Kcal/mole--and in the terminology used to describe quantum numbers in the PSs as compared to the CHEM Study textbook caused too many difficulties for both the students and the teachers in Chapter 15. Perhaps the programmed material in Chapter 15 required more direction than was given, or perhaps was too difficult to the point where students merely copied responses, or did not in some way qualify as the type of adjunctive PI proposed for the present study. If PI is to play only a small part in the total instructional sequence, and if the teacher is not going to teach directly from the programmed textbook then perhaps the programmed materials should be selected carefully in order to have them match quite closely the regular textbook material. Just how close the match should be depends on the roles that both the PI and the teacher are to take (see below).

Chapters 5 and 6 of the PSs expand on the presentation of "Lewis Diagrams" and "Orbital Diagrams" in such a way as to reinforce most of the other topics covered in Chapter 16 of the textbook. Without presenting anything new the PSs horizontally supplemented the textbook by providing practice with Lewis and orbital diagrams of common molecules. Apparently in this type of situation teacher direction is required for a higher level of achievement. Care should

be taken not to generalize the results of the present study to situations where lower-level drill PI or where initial PI alone is employed in the classroom.

Later in this chapter the teachers' opinions are presented and combined with the above results to provide a basis for conclusions and recommendations.

Treatment Effects on Student Attitude

Results

The student attitude measure consisted of fourteen statements regarding the PSs and their use as an adjunct to CI. The frequency distributions on the five point Likert Scale were examined by inspection and where possible by using the Chi-square statistic.

Table 5 presents the frequency distributions (in percentages) for each statement for all of the students who responded to the instrument in the initial administration (N = 276).[2] Comparisons of response frequencies on the dimensions--preview-review, directed-nondirected, initial-final, and teachers--proved to be largely non-significant in both a statistical and a simple inspection sense. The most important and interesting comparison of responses was that of A students, B students, and C students.[3] The response results for each statement are presented below and in Table 6. First the total response frequencies are given and then any relevant comparisons of the student

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2. The initial and the final responses as a group were almost identical.

3. Students were classified by their Chemistry 10 mark as reported by them.

Table 5

Percentage Frequency Distributions of Student Reactions to the Statements on the Student Attitude Measure**

	Statement	SA*	A	U	D	SD
1	The PSs should be used to review the teacher's presentation of a chemistry topic.	20	55	16	7	2
2	The immediate feedback of the answer (by simply turning the page) assists learning.	17	57	9	13	4
3	More teacher assistance during class time is required with specific questions in the PSs.	8	52	15	22	1
4	The assignments should be marked for the number of questions answered right or wrong.	2	14	18	37	29
5	More time (in terms of the number of days that you have the text) is required to complete the assignment.	16	44	15	23	2
6	The steps (i.e. the progression from one question to the next) in the PSs are too large.	4	14	23	51	8
7	The PSs help clear-up difficulties encountered in the classroom presentation.	10	48	19	20	3
8	There is too much repetition within the PSs.	6	18	21	44	11
9	The PSs should be used during class time to replace the teacher's regular presentation.	7	20	20	31	22
10	Most of the questions are difficult.	5	29	14	48	4
11	The subject matter in the PSs is very close to the same as that presented by the teacher.	4	47	25	20	4
12	The PSs provide too much extra work.	4	25	21	43	7
13	The PSs should be used prior to the classroom presentation of a chemistry topic.	10	22	20	35	13
14	The answer is too available, which results in looking for the answer before the question is completed.	16	29	8	38	9

* SA - Strongly agree
A - Agree
U - Uncertain
D - Disagree
SD - Strongly disagree

** Percentages calculated from total student reaction frequencies on the initial administration of the instrument.

Table 6

Categorized Percentage Frequency Distributions of Student Reactions to the Statements on the Student Attitude Measure**

	Preview-Review					Directed-Nondirected					A, B and C Students				
	SA*	A	U	D	SD	SA	A	U	D	SD	SA	A	U	D	SD
1.	7	61	15	12	6 +	18	64	12	6	1 +	11	52	4	26	15
	21	60	8	10	1	9	55	11	18	7	13	67	14	3	3
											22	56	11	13	0
2.	14	53	13	16	4	21	53	11	14	1 +	19	56	7	15	4
	18	48	17	14	3	9	46	20	18	7	16	49	17	14	3
											15	52	15	15	4
3.	8	47	20	25	0	8	52	17	22	1	11	45	7	33	4
	8	56	14	20	2	8	50	18	23	1	6	64	13	16	2
											11	43	28	19	0
4.	2	15	12	48	23	5	20	16	34	25	0	20	15	45	22
	6	22	19	29	24	3	18	13	43	23	8	17	14	37	24
											2	22	19	33	24
5.	7	47	16	28	2 +	16	40	17	25	2	4	52	22	22	0
	24	36	18	20	2	16	42	16	23	3	14	48	16	21	2
											28	28	15	24	6
6.	1	15	22	56	6	4	13	18	57	8	0	11	15	59	15
	4	16	21	47	12	1	19	26	43	11	0	16	19	56	10
											6	20	24	45	6
7.	4	56	23	15	2	5	53	26	15	1	7	52	22	19	0
	9	43	28	18	2	8	45	24	19	4	5	51	24	17	3
											6	46	28	17	4
8.	4	31	14	47	4	7	25	21	43	4	15	26	19	37	4
	10	26	17	38	9	7	32	11	41	9	6	29	13	46	6
											4	30	17	45	6
9.	2	12	17	45	24	5	13	21	42	19	4	11	15	26	45
	10	18	18	32	22	8	18	13	32	28	6	21	16	35	22
											11	15	19	41	15
10.	0	27	17	55	1	1	31	12	54	2	0	15	15	63	7
	4	30	16	48	2	4	26	22	47	1	2	33	16	48	2
											4	33	19	45	0

Table 6 (continued)

Categorizes Percentage Frequency Distributions of Students Reactions to the Statements on the Student Attitude Measure**

	Preview-Review					Directed-Nondirected					A, B and C Students				
	SA*	A	U	D	SD	SA	A	U	D	SD	SA	A	U	D	SD
11.	0	58	17	21	4	0	53	22	24	1	0	41	33	26	0
	0	43	25	26	6	0	46	22	23	9	0	51	19	25	5
											0	56	17	24	4
12.	4	19	14	59	4+	9	23	15	48	5	20	15	15	48	4
	18	27	14	34	7	13	23	15	43	5	10	8	17	57	8
											13	39	13	32	4
13.	7	33	7	39	14	8	27	7	45	13	11	30	7	37	15
	10	23	11	47	9	9	30	12	39	9	11	22	13	48	6
											4	28	6	52	11
14.	18	28	12	28	14	11	23	12	34	20+	20	15	4	41	22
	16	30	8	33	13	24	38	17	26	5	11	29	11	38	11
											17	39	11	19	15

* SA - Strongly agree
A - Agree
U - Uncertain
D - Disagree
SD - Strongly disagree

** Percentages calculated from student reaction frequencies on the final administration of the instrument.

+ Chi Square $p < 0.05$

categories mentioned above are made. The statements have been reordered to approximate the strength of the students' reactions to the statements.

Statement 1 examines the desire of the students to have the PSs used as review to the teachers' presentation of a chemistry topic. Seventy-five percent of the students either "strongly agreed" or "agreed" with the statement which positively suggested review use of the PSs. As indicated by Table 6 all three student achievement levels showed a preference for review use of the PSs but the A students were more split in their responses than the other two student achievement levels.

Statement 2 response frequency percentages for the total group of students indicate that seventy-four percent of the students "strongly agreed" or "agreed" with the statement that immediate feedback of the correct response assists learning. The student achievement levels were almost identical in there response distributions. The greatest difference on any comparison of the three sets of student categories appeared between the directed and nondirected students. The directed students showed a greater preference (seventy-four percent to fifty-five percent) for the immediate feedback of the correct response.[4]

Statement 3 results indicate that the students wanted more teacher assistance or direction with specific questions in the PSs regardless of whether they were in a teacher-directed class or in a nondirected class. Although a majority of A students wanted more

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4. This result has greater importance and is partially explained when combined with other results below.

teacher assistance, a smaller proportion of A students than of B students (fifty-six percent compared to seventy percent) wanted more assistance.

Statement 4 results show that the greater proportion (sixty-six percent) of all students disagreed with the statement that the assignments should be marked for the number of right or wrong responses. A slightly greater proportion of preview, as compared to review (seventy-one percent compared to fifty-three percent), students disagreed with marking the assignment.

Statement 5 results help confirm, from a student point of view, the earlier speculations about homework time on a compressed semester. Students, particularly C students and review students, felt that a greater length of time was required to complete the assignment from the PSs.

Statement 6 results indicate that the greater proportion (fifty-nine percent compared to eighteen percent) of students found that the step size was not too large. However more of the C students (compared to A and B students) and the nondirected students (compared to directed students) found the step size too large.

Statement 7 results show that by a better than two-to-one margin students thought that the PSs helped to clear up difficulties encountered in the classroom presentation.

The responses for the remainder of the statements indicate that the greater proportion of all students thought that 8) there was not too much repetition in the PSs (although the A students were split half and half); 9) the PSs should not replace the teachers' regular

presentation (forty-five percent of the A students "strongly disagreed"--the strongest reaction to any statement); 10) most of the responses required in the PSs were not difficult (the A students and the directed students reported less difficulty); 11) the subject matter of the PSs was very close to that presented by the teacher; 12) the PSs did not provide too much extra work (the review students and the C students were split in their responses); and 13) the PSs should not be used prior to the classroom presentation of a chemistry topic (the A students were split in their responses but the C students were more decidedly opposed to preview use of the PSs).

The almost fifty-fifty split or responses to Statement 14 for all students proved to be a result of an opposing trend in responses between A and C students. More A students reported that they did not find themselves merely copying responses whereas more C students found that they were. Directed students indicated that they copied responses less than was indicated by the nondirected students (thirty-four percent compared to sixty-two percent). This perhaps explains why the Statement 2 results showed that directed students liked the feedback of results better than the nondirected students did.

Discussion

In summary, the results show that the students generally approved of PI; the A students and the directed students reported the least difficulty with the programmed materials. Most students did not think that the PSs provided too much extra work, but would have liked more time to complete the assignment. The students indicated that they would prefer to have more teacher assistance and would like the PSs to

be used as review rather than preview.

These results are most revealing not in themselves but rather when combined with the achievement test results which favoured the teacher-directed approach but showed no significant differences in achievement between preview and review groups. Before considering the relationship of these results further, the teacher questionnaire results are presented and discussed. In concluding the chapter a summary and discussion of the relationship of the three sets of results is undertaken.

Teacher Questionnaire Results

Copies of the initial and final teacher questionnaires appear in Appendix E and Appendix F. The results presented and the conclusions reached in this section are a result of examining the free responses of the three teachers.

Results

The teachers in the present study each used the PSs adjunctively to their CI in each of the four ways defined by the 2 x 2 design. As a result of their experiences within the present study the teachers unanimously preferred the teacher-directed approach over the nondirected approach and the review presentation over the preview presentation of the PSs. This preference was the same as that of the students and reinforces the significant difference in achievement favouring the teacher-directed approach.

Perhaps the most significant evidence collected in regard to the acceptance of PI was the effort made by the teachers to obtain PSs

for teaching chemistry in the coming year. One teacher had a class set of PSs bought for his use through the school budget. Another teacher has proposed his own research study on the adjunctive use of PI, and has requested the use of a class set of PSs for his regular classroom instruction.[5]

Teachers generally agreed with the students that the terminology differences between the PSs and the CHEM Study textbook caused difficulties in regard to student learning, that the preview, nondirected, and low ability students had the most difficulties, and that the programmed materials were in general easy to follow and complete. The teachers confirmed the opinions expressed earlier about the disadvantages of the compressed semester and about the differential agreement in terminology between the PSs and the textbook on Chapter 15 and 16.

Review use of the PSs was supported by the teachers for two reasons. First, the teachers felt that the difficulty and the intent of the programmed material used required prior teacher instruction, particularly if the students were having difficulty relating the subject matter of the PSs to the textbook.

Second, the teachers indicated that the students tended to spread further apart in terms of knowledge and understanding of the chapter content as the instructional sequence of the chapter progressed. Independent study using the PSs as review assists the teacher in solving this instructional problem by allowing the student to work at

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5. The third teacher is returning to university and is not teaching in the coming school year.

his own pace and to concentrate on the part of the subject matter which is currently causing him problems.

Another teacher comment concerned the novelty effect of PI for students using PI adjunctively to CI. The suggestion was made that the novelty effect may be used to advantage and is perhaps longer lasting when PI is used adjunctively rather than as the sole means of instruction.

The teachers reported instances of students completing the whole programmed text rather than merely completing the assigned work. Student comments to the teachers on PI included "interesting way to learn on my own", "good way to review", "helped me to understand" and "the drill helped".

When the teachers were asked whether or not and how they might change their regular instructional practices because of the use of the <u>PSs</u>, they suggested that changes would depend upon the chemistry topic and the type of PI used. For example, the chapters in the <u>PSs</u> used supplementary to CHEM Study Chapter 13 would perhaps allow the teacher to entrust the initial instruction to the <u>PSs</u>. This example was suggested for two reasons. First, the chemistry topic is stoichiometry, which involves a large amount of drill. Traditionally PI has proven to be a useful tool for providing drill, perhaps because the programming of this type of material is easier.

Second, teachers are willing to turn drill work of the type in Chapter 13 over to PI because they become bored with repeating simple facts to class after class. In such cases there is a greater chance of the PI taking over the initial instruction of a topic rather than

repeating what CI has already done or will do. The teachers in the present study could only speculate on the question of how PI might change their regular practices since they were asked not to change their regular practices and since the programmed materials were not primarily of the simple drill type.

The remainder of the teacher questionnaire obtained information on the teachers' opinions on classroom research in general and on the specific procedures followed by the teachers in the present study. The teachers indicated that they had been able to follow quite accurately the definitions of the treatments given in Chapter I and the experimental procedures outlined in Chapter III. Further evidence to support the above was obtained through the records of actual activities and time spent on the PSs which were kept by each teacher for each class.

Discussion

The teacher questionnaire results are important both in that they support the achievement results and for the reason of adding greater credibility to the achievement results as far as generalizability to the conventional classroom is concerned. That the teachers reacted favourably to the intrusion of PI into their classroom and made plans to continue using adjunctive PI in their chemistry courses is regarded as an important result of the present study.

The reader should keep in mind the specific treatment definitions employed, the variables manipulated, and the type of PI used in the present study when attempting to generalize the results to classroom situations. However the teachers' reactions indicated that in their opinion practical and important classroom variables had been manipulated

in the present study and that the results obtained should be important to the majority of classroom applications of PI.

Summary of the Results

Specific to the PI, the subject matter, and the treatments employed in the present study it was found that the teacher-directed approach to using PI adjunctively to CI produced significantly greater achievement than the nondirected approach when Chapter 16 achievement test scores were used as the criterion measure. The students agreed that teacher direction of the use of the PSs was desirable and indicated that they would like even more teacher direction than they had been given. The consensus of the teachers was that they should take an active part in relating the subject matter of the PSs to that of the CI, and in assisting the students in whatever manner possible. The amount of teacher direction desirable seems to depend upon the ability and perhaps the sex of the students and on how closely the programmed materials match the subject matter of the CI.

On the time of presentation variable no significant difference in achievement was obtained between the preview and the review groups. However both the teachers and the students indicated a strong preference for the review use of the PSs.

The analysis of covariance did not uncover any interaction between the treatment variables although a significant interaction favouring female students with the directed approach and male students with the nondirected approach was obtained when the Chapter 15 test scores were used as the criterion measure.

The teachers and the students both reacted favourably to the use of PI adjunctively to CI. In the opinion of the teachers the independent treatment variables manipulated were practical classroom variables and the adjunctive use of PI should receive widespread application in the conventional classroom.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

Past research has shown that PI used adjunctively to CI has produced significantly greater achievement than CI alone. The present study has attempted to begin a search for the optimal method of presenting adjunctive PI by manipulating the amount of teacher direction (directed versus nondirected) and the time of presentation (preview versus review) when PI is used adjunctively to CI. The CI was held constant by having each of the three teachers use the adjunctive PI in all of the four ways defined by the 2 x 2 factorial design. The teachers were asked not to change their regular practices other than providing classwork and homework time for the completion of the PI assignments.

A programmed textbook which contained horizontally programmed chemistry materials was employed adjunctively to Chapters 13, 15 and 16 of the CHEM Study textbook. The programmed materials repeated the instruction of part of what the teachers presented by requiring the students to respond to programmed frames which provided a horizontal extension of the CI.

The data gathered consisted of Chapter 15 and 16 achievement test scores, student reactions to PI in general and to the manner in which the PI was presented, and teacher opinions on the use of PI adjunctively to CI.

A two-way analysis of covariance procedure using Form 3A SCAT scores as the covariate was employed with the Chapter 15 and 16 achievement scores as separate criterion measures. A significant difference in achievement ($p < 0.05$) favouring the teacher-directed over the nondirected approach was obtained when the Chapter 16 achievement test scores were used as the criterion measure.

The students and the teachers indicated that on the basis of their experience in the present study adjunctive PI was regarded as beneficial to learning and should be used as a teacher-directed review to the CI. More teacher-direction appeared to be required for low ability students and for PI which varies considerably from the CI in terms of subject matter and terminology.

Conclusions

On the basis of the achievement score results and the expressed opinions of the teachers and students in the present study, it may be concluded that the adjunctive use of PI in high school chemistry is a desirable practice in enhancing student achievement. The adjunctive PI employed produced significantly greater achievement when the necessary amount of teacher direction was provided. The most favourable teacher and student reactions were obtained when adjunctive PI was used as review rather than preview and by a teacher-directed rather than a nondirected approach.

Recommendations for Classroom Practice

The concern expressed in Chapter I regarding "practical"

generalizability of results permeates most educational research studies when making recommendations for classroom practice. An attempt was made in the present study to employ practical classroom variables, to require only a small role change for the classroom teacher, and to solicit the teachers' opinions with regard to generalizability of results in order to increase the chances of actually having the results and recommendations accepted by classroom teachers.

The researcher recognizes that the results of the CI plus PI-versus-CI studies reviewed in Chapter III[1], as well as the results and recommendations of the present study, must be communicated to classroom teachers before it is possible for them to make any decision on the use of PI in their own classrooms. Therefore the researcher recommends that teachers be informed of the adjunctive PI research through university curriculum and instruction courses, pedagogical publications, Department of Education curriculum guides, and in-service-training sessions.[2]

A second obstacle for teachers who want to use adjunctive PI in their classrooms is the problem of purchasing the necessary programmed textbooks. The alternatives are to have the programmed materials purchased by the library, by the students, or by the school.

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1. Seven out of seven of the studies reviewed in Chapter III reported a significant difference in achievement favouring CI plus PI over CI alone.

2. The researcher has made plans to write an article for the SCAT Bulletin, to conduct an in-service-training session for Edmonton chemistry teachers, and to communicate with the Alberta Department of Education on the adjunctive use of PI in chemistry.

In the latter case the materials could then be rented or loaned to the students.

The experience of the teachers with adjunctive PI in the present study led them to express the opinion that practical classroom variables were manipulated. The teachers' desire to continue using PI in their classroom indicated that they were willing to accept PI and would make an effort to obtain programmed material for their classroom use. Furthermore, the teachers reinforced from an administration and learning standpoint the statistical results of the present study.

On the basis of the research reviewed in Chapter II it is recommended that PI be used adjunctively to CI. The students' and teachers' opinions in the present study support this recommendation.

The central concern in the present study was to determine, within the limits defined by the treatment variables, the optimal method of utilizing PI adjunctively to CI. The results suggest that PI of the type used in the present study should be presented as review rather than preview to CI and by a teacher-directed rather than a nondirected approach. The recommendation is based on an assumed desire to increase the achievement level in high school chemistry. What might come after this increase in achievement in terms of changes (if any) in the roles of the teacher and students remains for further research and debate to determine.[3]

The sequential nature of chemistry requires that the student have a good grasp of basic concepts before proceeding to higher level

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3. Recommendations for changes in content emphasis are reviewed and discussed in Chapter II.

concepts. In this sense the degree of mastery of instructionally-current concepts will influence how close the students and the teachers can come to achieving the goals for subsequent concepts and ultimately for the chemistry course.[4] PI may help to solve the problem of prerequisite learning by providing the drill and practice in the applications of a concept necessary for the students to obtain an understanding and an adequate level of mastery of the concept. PI could in the future replace the worksheets and the teacher's drill sessions in chemistry courses, and may in this way increase achievement while freeing the teacher for other duties.

An application of PI which approximates the use of adjunctive PI in the present study is that of using PI to review the subject matter of a previous course. For example, at the beginning of Chemistry 30 programmed materials such as the PSs may be used to review (with teacher direction) the Chemistry 20 course. This application would be supported by the results of the present study in that the PI would be used as review and would be teacher directed. The variability in the chemistry backgrounds of the students could perhaps be reduced and the teachers could be released from a boring review to provide individual assistance to students (especially to low ability students).[5]

Many applications of PI are possible as a result of having programmed materials available because of the applications described

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4. The same statement may be made about any content area (such as physics) which contains sequential concepts.

5. The researcher has found this application to be quite beneficial in his own Chemistry 30 classroom. The students have reacted very favourably toward this application.

above. For example, programmed materials may be used to assist students who require remedial work, have missed chemistry classes, or desire enrichment. PI used in such situations provides a definite and clear assignment for these students, but would require teacher direction perhaps to an even greater degree than employed in the present study.

When different applications of PI are employed it is important that the type of programmed material and the teacher's role be suited to the situation. This requirement is discussed in the concluding section.

Recommendations for Further Research

1. Since the present study cannot be considered the final answer on how to employ PI adjunctively to CI in chemistry, the first recommendation must be to replicate the present study. The treatment variables manipulated have emerged as important and practical classroom variables and any questions concerning the results of the present study should therefore be dealt with. The replication could begin by employing PI similar to that used in the present study in order to keep the PI variable constant and to allow comparison of results for different groups of subjects.

2. Modifications to the teacher-direction variable could include attempts to discover the optimal amount of teacher direction which would maximize student achievement. The students in the present study indicated that they would prefer to have more teacher assistance, but would this move increase student achievement? Perhaps the low ability students could be identified early in a course and a research

study conducted to compare achievement when the teacher concentrated his assistance on these low ability students.

3. The results of the present study suggest that the amount of teacher direction and the time of presentation of the PI should be determined by the type of PI used and the chemistry topic being covered. CI plus PI-versus-CI plus PI research could answer the question as to whether PI of the type written by Powell (1963)[6] might require less teacher direction and might be used earlier in the instructional sequence than the PSs used in the present study.

4. Following or included in replications of the present study, studies using a CI plus PI-versus-CI format may compare the optimal CI plus PI combination to CI alone. As mentioned in Chapter II the CI in past research has varied considerably, as has the grade level of the students. It would be valuable to have CI plus PI-versus-CI studies conducted using similar CI and PI to that employed in the present study. Such studies might also explore variations in the CI such as the type of regular textbook used. Are the results of the present study specific to the use of CHEM Study textbook?

5. Another extension of the present study, which could be made once an optimal presentation method has been identified, would be to study possible role changes for the teacher. For instance, research could determine whether teachers might spend more classroom time on developing a greater appreciation and understanding of chemistry, and

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6. Lower level chemistry topics such as calculating molecular weights, and writing molecular formulae are programmed by Powell with a quite small step size and a low error rate.

yet maintain the same level of achievement for current goals while increasing the level of achievement for goals currently de-emphasized or nonexistent.

6. A variety of dependent variables could be measured in any of the research studies recommended above. Student dependency, the extent of individualized instruction, and any change in the teachers' perception of their professional role might be measured in addition to achievement and student and teacher reactions to PI.

7. Klaus (1961:132) suggests that there are several levels of programming. Rote learning of facts of history, foreign language vocabulary, and spelling through programmed materials constitutes an example of low level programming. "Conceptual learning" in chemistry, physics and statistics and "creative thinking and judgment" are described by Klaus as requiring higher level programming. One might ask, what is left for the teachers to do? The present study and past research suggests that PI and CI should be integrated. Further research should indicate the role of PI and the teacher at each of the levels of programming. For example when low level programming is used, should the teacher cover the rote materials in his regular classroom practices? The rote-learning programmed materials might provide the initial and only instruction on the subject-matter topic but might be accompanied by some teacher direction. The results of the present study indicate that conceptual learning by PI requires that the PI repeat the materials covered by CI and that teacher assistance with the PI be given. Instruction to increase the students' ability in creative thinking or in using the higher cognitive processes might be

assisted by PI, but by extrapolating the above trend higher level learning might prove to be the task of the teacher without PI. The role of the teacher and of PI at each level of learning needs to be clarified further through research. The research would probably take the form of CI plus PI-versus-CI plus PI studies for intermediate levels. of programming but could change to CI plus PI-versus-PI or CI studies for the extreme (upper and lower) levels of programming.

8. Popham (1964:65) speculates on a further relationship between PI and CI by suggesting that "a teacher's exposure to the methods of programmed instruction can provide a stimulus of sufficient strength to affect a teacher's usual instructional methods." The influences of PI on the teacher and subsequently on CI that are suggested by Popham are:

a) the emphasis on operational instructional goals by PI may lead the teacher to define the goals of his CI more clearly than he presently does.

b) the teacher may place more stress on having the students make active response after witnessing the benefits of this when using PI.

c) the importance placed upon immediate knowledge of results in PI may influence the teacher to use this instructional tactic in their CI.

d) the stress on self-pacing or individual differentiation seen in PI may be translated into conventional instruction practice.

e) the teacher may begin to accept the responsibility for student failures just as the programmer of PI must.

f) the teacher may develop more of a "curriculum concern" for the content and the objectives of his instruction when he realizes the increased effectiveness of his instruction and the effect his instruction may have on his students.[7]

Popham sees the above influences of PI on CI as being advantages in the quest for an increased quality of instruction. However it remains for research to determine whether the influences actually occur and to what extent, and whether the influences do in fact increase the quality of instruction as measured by achievement or other dependent variables.

A similar view to that of Popham's is expressed by Porter (Perkins, 1970:72):

> Some educators think of programmed instruction as another 'medium' of instruction, like television or tape. It is not. Programmed instruction is a process for the specification, design, perfection, and validation of instruction, a process which is applicable to all media. The full implications of programmed instruction can be appreciated only when this point is understood.

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7. The assumption is being made here that the influences of PI on CI may increase the effectiveness of CI to the point where students will be more easily shaped or influenced by the subject matter and the teacher's opinions.

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APPENDICES

APPENDIX A

Table 7

Two-Way Analysis of Covariance on Chapter 15 Scores for Male-Female and Directed-Nondirected Variables

Source	SS	DF	MS	F-RATIO	P
M-F	71.16	1	71.16	7.22	0.01
D-ND	7.55	1	7.55	0.77	0.38
M-F x D-ND	43.96	1	43.96	4.46	0.04
COV	275.31	1	275.31	27.95	0.001
ERROR	2166.68	220	9.85		

Table 8

Two-Way Analysis of Covariance on Chapter 16 Scores for Male-Female and Directed-Nondirected Variables

Source	SS	DF	MS	F-RATIO	P
M-F	3.70	1	3.70	0.15	0.70
D-ND	158.17	1	158.17	6.43	0.01
M-F x D-ND	1.03	1	1.03	0.04	0.84
COV	1280.93	1	1280.93	52.08	0.001
ERROR	5410.93	220	24.60		

APPENDIX B

Chapter 15 Achievement Test

50 Minutes
Each question is worth 2 marks.
Choose the best answer for the following questions.
Put your name on both the question and answer sheets.

Name: ____________________

Teacher: ____________________

Block: ____________________

1. Which of the following electron transitions would release the most energy?

   (A) 4th level to 2nd
   (B) 2nd level to 1st
   (C) 1st level to 4th
   (D) 3rd level to 1st (______)

2. The maximum number of electrons in a level with a principle quantum number of four is

   (A) 8
   (B) 16
   (C) 32
   (D) 64 (______)

3. Light of a characteristic energy is emitted by an atom when an electron

   (A) is raised to a higher energy level
   (B) moves to a certain energy level
   (C) drops to a lower energy level
   (D) increases its velocity (i.e. accelerates) (______)

4. An atom of element X has the electron configuration

   $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$. The number of valence electrons and the atomic number of the element are respectively

   (A) 4 and 12
   (B) 6 and 12
   (C) 6 and 16
   (D) 4 and 16 (______)

5. An atom of an element has the electron configuration

   $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^7$. The total number of

occupied p orbitals and the number of unpaired electrons are respectively

(A) 2 and 2
(B) 6 and 3
(C) 2 and 7
(D) 6 and 7 (_______)

6. Which of the following atoms would have a nonspherical electron distribution?

(A) Li
(B) Be
(C) B
(D) H (_______)

7. Which of the following do NOT all have the same electron distribution?

(A) $O^{=}$, F^{-}, Na^{+}, Mg^{++}
(B) F^{-}, Mg^{+2}, Ne, Na^{+}

(C) Al^{+3}, Ne, F^{-}, $O^{=}$

(D) K^{+}, S^{-}, Ca^{++}, Ar (_______)

Questions 8 through 10 have to do with the following information: Atoms A, B, C, D are in the same period of the periodic table and have one, three five and seven valence electrons respectively.

8. The atom with the highest second ionization energy is

(A) A
(B) B
(C) C
(D) D (_______)

9. The atoms with only one unpaired electron in the ground state (lowest energy state) is

(A) A, B and D only
(B) A and D only
(C) B and C only
(D) A, B, C and D (_______)

10. The two atoms which are chemically most reactive are

(A) A and B
(B) B and C
(C) C and D
(D) D and A (_______)

11. Which of the following is NOT a factor in determining the ionization energy of an atom?

(A) nuclear charge
(B) extent of filling of the orbitals
(C) the atomic mass of the atom
(D) principle quantum number of the valence electrons (_______)

12. A H atom and a He_1^+ ion both have the same electron configuration ($1s^1$). Which of the following is true concerning energy level differences?

(A) E_2-E_1 for H is greater than E_2-E_1 for He^+.

(B) E_2-E_1 for H is less than E_2-E_1 for He^+.

(C) E_2-E_1 for H is equal to E_2-E_1 for He^+.

(D) E_2-E_1 for H can be equal to or less than E_2-E_1 for He^+ (_______)

13. How many spectral lines can result from electron transitions involving the N = 1, 2, 3 and 4 energy levels of a hydrogen-like atom?

(A) 3
(B) 4
(C) 5
(D) 6 (_______)

Questions 14 through 15 have to do with the following information:

An atom has an electronic configuration of $1s^2 2s^2 2p^3$ and an ionization energy of 335 kcal/mole.

14. What would Niels Bohr have calculated as the energy of an electron in the third principle energy level?

(A) -37.2 kcal/mole
(B) -313.6 kcal/mole
(C) -34.8 kcal/mole
(D) -278.8 kcal/mole (_______)

15. What would Niels Bohr have predicted as the energy released when an electron drops from energy level n = 2 to energy level n = 1?

(A) 335 kcal/mole
(B) 34.8 kcal/mole
(C) 235 kcal/mole
(D) 251 kcal/mole (_______)

16. The first four ionization energies for an atom are 135, 260, 1275 and 2013 kcal/mole. From which group in the periodic table does this atom come?

(A) Group I
(B) Group II
(C) Group III
(D) Group IV (______)

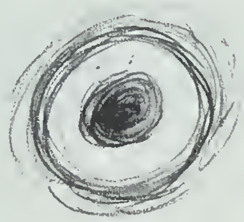
17. Which of the following is not a hydrogen-like atom?

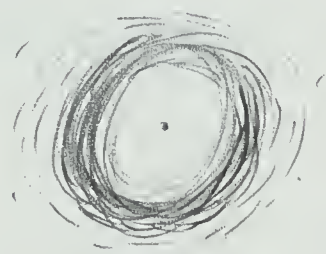
(A) H^-
(B) Li^{++}
(C) He^+
(D) Be^{+3} (______)

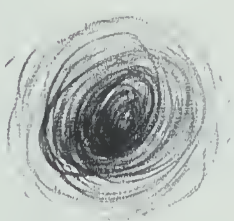
18. The ionization energy for one particular hydrogen-like atom is 580 kcal/mole. If an electron was in an excited state at the n = 3 energy level, what would be the additional energy required to remove this electron from the atom?

(A) 193 kcal/mole
(B) 64.4 kcal/mole
(C) 516 kcal/mole
(D) 580 kcal/mole (______)

19. An extremely thin cross-sectional slice if taken of a 2s orbital. (Included in the slice is the nucleus of the atom.) Which of the following is the best representation of the electron probability distribution as determined by this slice?

(A)


(B)


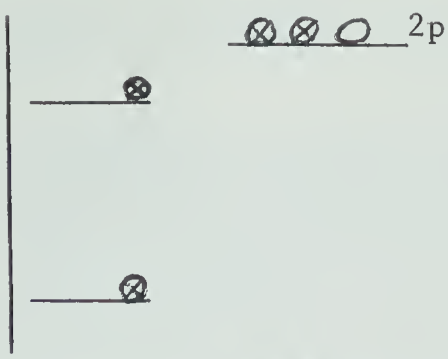
(C)


(D)

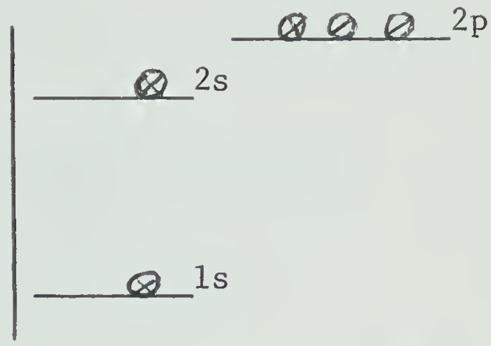

(______)

20. An atom has an atomic number of 8. Which of the following energy level diagrams represents this atom?

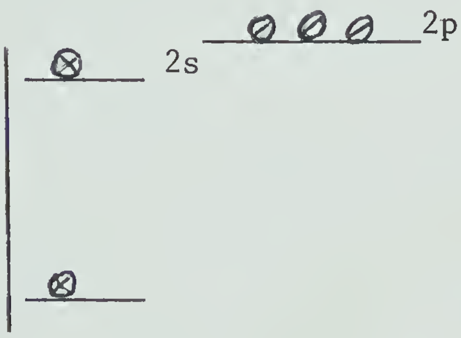
(A)



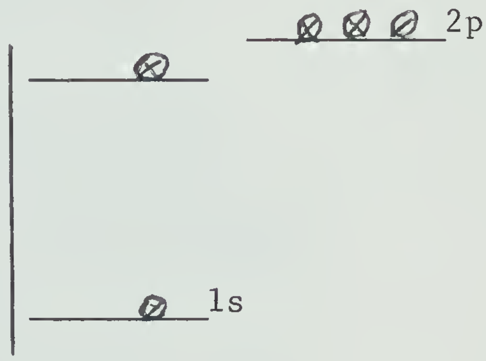
(B)



(C)



(D)



(______)

21. The type of orbitals following f in the s, p, d and f notation will be known as the g orbitals. Scientists have not as yet discovered an atom with a large enough atomic number to contain g orbitals in the lowest energy state. What would be the predicted maximum number of electrons necessary to fill all of the g orbitals in a particular energy level?

(A) 9
(B) 14
(C) 32
(D) 18 (______)

22. If we are to remove a single 2s electron from one of the following neutral atoms, then in which atom would we require the most energy?

(A) Mg
(B) Ca
(C) K
(D) Na (______)

23. What will be the atomic number of the next inert gas element discovered?

(A) 104
(B) 113
(C) 118
(D) 108 (______)

24. When we examine a period in the periodic table in terms of first ionization energy we notice a general increase (p. 268). There are however a number of exceptions to

this general increase. An explanation for the exceptions could be:

(A) an unequal increase in nuclear charge of the atoms.
(B) an additional stability of filled and half-filled sets of orbitals (or subshells).
(C) an extra amount of shielding of the electrongs from the nucleus.
(D) the removal of the second, third and fourth electrons causes the shifting. (_______)

25. In a non-hydrogen-like atom the s, p and d orbitals within the same principle energy level are not of equal energy. Selection rules proved by spectrographic experiments indicate that electron transitions between like type of orbitals is not allowed (i.e. NO electron transition is allowed from a 2s orbital to a 1s orbital). Following this rule how many spectral lines might be observed from electron transitions involving the s and p orbitals with n = 2, 3 and 4 principle quantum numbers?

(A) 8
(B) 14
(C) 11
(D) 5 (_______)

APPENDIX C

Chapter 16 Achievement Test

50 minutes
Each question is worth 1 mark.
Put your name on both the question and answer sheets.
Choose the best answer in Part I & II.

Name: ______________________

Teacher: ____________________

Block: ______________________

I. Which of the following (in questions 1 - 10)

1) contains both covalent and ionic bonds?

(A) CH_4

(B) $CaCl_2$

(C) NH_4Cl

(D) H_2O (______)

2) contains no polar bonds?

(A) C_2H_6

(B) CCl_4

(C) NH_3

(D) O_2 (______)

3) exhibits ionic bonding?

(A) Cl_2

(B) BaO

(C) SO_2

(D) ClF (______)

4) contains a triple bond?

(A) HCN

(B) SO_2

(C) C_2H_4

(D) BeF_3 (______)

5) contains a double bond?

(A) F_2O

(B) BaF_2

(C) BaO

(D) CS_2 (______)

6) contains only one unshared pair of valence electrons?

(A) H_2O

(B) NH_3

(C) CH_4

(D) NaCl (______)

7) has the highest molecular electric dipole?

(A) CCl_4

(B) BCl_3

(C) OCl_2

(D) $BeCl_2$ (______)

8) is most stable (i.e. in lowest energy state and least reactive)?

(A) HCl

(B) CH_2

(C) OH

(D) C_2H_4 (______)

9) exhibits p^2 bonding?

(A) H_2O_2

(B) CO_2

(C) ClF

(D) NH_3 (______)

10) exhibits a triangular planar molecular shape?

(A) BF_4^{-1}

(B) $BeCl_3^{-1}$

(C) NH_4^{+3}

(D) H_3O^+ (______)

11) From Table 15 - III on page 268 determine which of the following bonds is most ionic?

(A) C-N
(B) N-O
(C) C-O
(D) N-F (______)

12) The shape of the CO_2 molecule is

(A) tetrahedral.
(B) bent.
(C) linear.
(D) triangular planar. (______)

13) Breaking a bond

(A) requires energy.
(B) produces energy.
(C) releases energy.
(D) lowers the energy. (______)

14) The Argon atom exhibits what type of bonding?

(A) sp^3

(B) ionic

(C) p^3

(D) none of the above (______)

15) "Promoting" of an electron from an s to a p orbital to produce hybridization (i.e. sp^2 bonding orbitals) is energetically possible because:

(A) energy is released from the electron transition.
(B) electromagnetic radiation is supplied to the electron.
(C) the extra bonds formed will lower the atomic energy.
(D) the isolated atom is now stable and less reactive. (______)

16) Which of the following is not a reason for Helium being monoatomic rather than diatomic?

(A) the electron and proton repulsions are greater than the attractions.
(B) the H value for $He+He \leftrightharpoons He_2$ is negative.
(C) the valence orbitals are filled.
(D) the energy in the monoatomic form is lower. (______)

II. MATCHING (Determine the overall best fit.) Put your answers on the question sheet in the space provided.

17) N_2 ______	(A) tetrahedral shape
18) NO ______	(B) ionic bond
19) SiH_4 ______	(C) single covalent bond
20) CO_2 ______	(D) bent molecule
21) I_2 ______	(E) triple bond
22) $SrCl_2$ ______	(F) residual bonding capacity
23) PCl_3 ______	(G) sp bonding
24) H_2O ______	(H) p^3 bonding

III. Draw electron dot diagrams for the following:

25) MgH_2

26) PCl_3

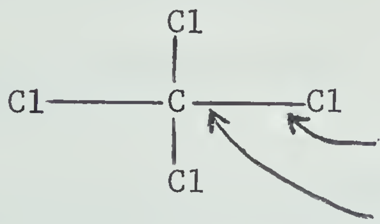
27) PO_3^{-3} ion

28) C_2H_2

IV. Draw actual orbital representations of atomic orbital bonding within the following molecules. Show orbital overlap and electron occupancy of the orbitals. As in Programmed Text of Fig. 16-10 in Chem Study text.

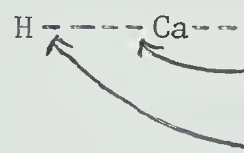
29) H_2S 30) BeF_2

V. A bond is formed by the overlapping of two valence orbitals. Label the following diagrams as to the type of orbitals undergoing bonding (i.e. s, sp, sp^2, sp^3).



31) ____________

32) ____________



33) ____________

34) ____________

TO CALCULATE MARK:

SECTION I	______	x	______	=	______
SECTION II	______	x	______	=	______
SECTION III	______	x	______	=	______
SECTION IV	______	x	______	=	______
SECTION V	______	x	______	=	______
TOTALS	______	x	______	=	______
POSSIBLE	34			=	______

PERCENTAGE

APPENDIX D

Student Attitude Measure

Please indicate your reaction to the following statements concerning the use of Programmed Supplements in Chem 20. Give your honest appraisal by putting a single check mark in the appropriate column-strongly agree, agree, uncertain, disagree and strongly disagree.

Chemistry 10 mark (circle) A, B, C

1. Most of the questions are difficult.
2. More teacher assistance during class time is required with specific questions in the PSs.
3. The PSs should be used prior to the classroom presentation of a chemistry topic.
4. The answer is too available, which results in looking for the answer before the question is completed.
5. The steps (i.e. the progression from one question to the next) in the PSs are too large.
6. The PSs provide too much extra work.
7. The immediate feedback of the answer (by simply turning the page) assists learning.
8. The PSs should be used to review the teacher's presentation of a chemistry topic.
9. The assignments should be marked for the number of questions answered right or wrong.
10. There is too much repetition within the PSs.
11. The PSs help clear-up difficulties encountered in the classroom presentation.
12. The subject matter in the PSs is very close to the same as that presented by the teacher.
13. More time (in terms of the number of days that you have the text) is required to complete the assignment.
14. The PSs should be used during class time to replace the teacher's regular presentation.

APPENDIX E

Initial Teacher Questionnaire

Please answer the following questions as best you can. There are two reasons for the questions: 1) to check the control of extraneous variables, and 2) to gather comments on the feasability of further research of this type being conducted in the intact classroom. Don't hesitate to be negative if this is the way that you feel.

1) Was the programmed material sufficiently similar to the Chem Study text material? Yes or No______
Comment:

2) Has the use of the Programmed Supplements interfered substantially with your regular classroom activities with respect to recording and reporting of research data? Yes or No______
Comment:

3) From an education point of view with respect to regular classroom teaching procedures has the use of the Programmed Supplements interfered substantially? (i.e. Would you use the Programmed Supplements along with your regular classroom practices after this research project is completed?) Yes or No______
Comment:

4) At this point what is your intuitive impression as to the best way of using the Programmed Supplements?

   a) Preview or Review?
   b) Directed or Non-directed?
   c) Others?

   Comment:

5) Were the exams used supervised? Yes or No______
Comment: (if any)

6) During the exams did the students use a) texts? Yes or No ______
b) notes? Yes or No ______
Comment: (if any)

7) Can you think of any extraneous variables which may effect the results of the research?
(i.e. type of testing, student cheating, student drop-outs, janitor strikes, student reaction to research situation, attendance, discipline problems, school social events, different teacher approach with different groups, student or teacher attitude toward Programmed Supplements -- these variables could have a positive or negative effect. The requirement of course is to minimize these extraneous variables or make them the same for all four approaches.)

APPENDIX F

Final Teacher Questionnaire

Refer to Preview-Review or Directed-Nondirected when necessary. State observations wherever possible. Do not infer that a particular answer is wanted.

Please explain any Yes or No answer whenever possible.

1. Were attempts made to omit parts of the subject matter content from teacher presentation because the content was covered in the Programmed Supplements?

2. Were parts of the content covered by a different instructional method (i.e. discussion rather than lecture or visa-versa) because the content was covered in the Programmed Supplements? To what degree? (This is not a "should" question -- that comes later.)

3. Was the material in the Programmed Supplements too difficult? Preview or review? Were the steps too large? Were the concepts difficult?

4. Was the content in the Programmed Supplements too different (to what degree)? Do you feel that this was detrimental to student achievement and/or attitude? How did the students feel?

5. Did you give less homework because of the use of the Programmed Supplements?

6. Do you think that the PSs provided too much homework for the student? What did the students think?

7. Do you think that the compressed semester was an advantage or disadvantage to the experimental design?

8. Did you have more time for lesson preparation (in class) and for you attending to individual differences because of the use of the PSs?

9. Did you rely on the PSs for review and drill rather than preparing your own hand-outs? (Compare to your usual practices without the PSs).

10. Did you assign less problems than usual from the regular text because of using the PSs?

11. Did you notice any extra (or less) participation, better questions, or boredom on the part of students who had used the PSs as preview?

12. Do you think that the use of the PSs with a compressed semester may effect the generalizability of the results to a non-semesterized classroom?

13. Did you conduct your own conventional preview or review with the class, independent of the PSs?

14. Did you change or partly omit your own conventional preview or review because of the use of the PSs? (Indicate if you do normally conduct a review -- which may include a) discussion, filmstrips, overviews or practice problems.)

15. What were the most common student complaints?

16. What were the most common student compliments?

17. What do you feel would be other methods of presentation of the PSs which might be beneficial? (i.e. individual cases only; to replace the teacher; neither as preview or review; on a voluntary basis.)

18. a) Do you think that the handing in of responses was necessary?

    b) Do you think that a written response is necessary?

19. How much cheating (i.e. merely copying responses) went on?

20. Did the low-ability students react any differently than the high-ability students in terms of a) attitude and b) work accomplished?

21. Do you prefer the use of the PSs for a) preview or review?
    or as b) directed or nondirected?

22. Do you think that this type of classroom study (i.e. research within the existing classroom) is useful a) for providing reliable research findings for making teaching more of a science? and b) for developing useful, practical instructional techniques? (Contrast with what you do or do not want to see in educational research.)

23. As a result of your experience (in this study) would you make an effort to obtain programmed material for use in your classroom?

24. Do you have any comments concerning the type of research conducted in your classroom? (Is it reliable, useful, generalizable, disruptive, or pertanent to the classroom.) Would you do this type of research again or would you recommend it to other teachers?

25. Did your ability to use the PSs increase from the first semester to the second? Comment from both an administrative point of view and a teaching point of view.

26. Do you have any further comments concerning the research that was conducted within your classroom -- specific or general?

APPENDIX G

Instructions for Students

1) You will be assigned a book with a certain number. Make sure that you receive the same book each time they are handed out. You are responsible for the possession and condition of the book. Do not leave it laying around.

2) Carry the book with you to every class period, just as you would the CHEM Study text: a) so that it may be used in class from time to time, and b) so that you will be certain to have it with you the day that it is to be handed in.

3) Make sure that you hand the book in on time. The number of the other class using the same book can not receive the book until you hand it in.

4) Regardless of how much the programmed text is used in the regular class period you are to regard it as part of the course. To complete full requirements for Chem 20 you must complete and hand in the prescribed questions as an assignment.

5) If you make an error or can not do a question go back one or more questions and re-do these to pick up what you missed. Your teacher will determine whether or not questions will be taken up during class time.

6) The assignment that you hand in must show both your answer <u>and</u> your work. You will mark your own answers as right or wrong. The assignment will NOT be marked on the basis of right or wrong answers. The main requirements are that the assignment should be done and your work should be shown.

APPENDIX H

Instructions for Teachers

1) Please do not confide to the students that this is a research project directed by someone outside the classroom. Indicate that you are "trying" the texts to improve classroom achievement, but try to stay away from discussing the experimental design.

   By making the situation natural you will increase the external validity of the experiment. The results will be more generalizable if the students do not react to the experimental arrangements (i.e. It will be less likely that the results could be attributed to the experimental setting rather than the specific experimental variables manipulated).

2) This research is also looking for the reaction of the teacher to the use of programmed supplements. A survey sheet shall be completed by the teacher, but it would be appreciated if teachers would convey their reactions (pro and con) to the experimenter. These reactions would be to such things as administration of the texts, interference with the conventional classroom practices, and applicability of the programmed material to the regular text material.

3) In order to establish the proper controls, all of the teachers will be required to use the same tests for the chapters where the programmed materials are used and will administer the tests as open book exams.

4) Keep in mind that we are searching for the best way to use the programmed material supplementary to the conventional classroom (and that there may be no best way). Please do not let any of your biases reach the students or in any other way effect the results of the research.

5) There are some questions or some parts of the programs which do not coincide with the CHEM Study subject matter. Therefore it has been necessary to eliminate these parts of the programs, or to instruct the students as to the difference. Some of the brighter students may wish to attempt the sections eliminated. (Studies have shown that achievement is in no way harmed by this type of acceleration or enrichment.)

   a) Ch. 13 Chemical Calculations - Ch. 2 in Programmed Supplements

      i) Instruct the students that 1 gram-atom of hydrogen means 1 mole of hydrogen atoms (1 gram-atomic-weight of hydrogen). This would be emphasized and illustrated in the DIRECTED

approach and merely pointed-out in the NON-DIRECTED approach.

ii) The rest of the chapter is OK and emphasizes the weight mole relationship as independent questions and as part of the questions involving chemical reactions. The problems are solved from the same approach as the CHEM Study text by converting into moles first.)

iii) Nothing is given on Avagadro's Hypothesis and gas problems.

b) Ch. 13 Chemical Calculations - Ch. 3 in Programmed Supplements

i) Do up to and including question number 32.

ii) The emphasis is on molarity as related to both ions and molecules in solution. Although some of the questions pertain to moles of hydrogen ions and hydroxide ions, there are not any specific references to neutralization/or acid-base) reactions. The reactions discussed are other than the neutralization type.

c) Ch. 14 Why We Believe in Atoms - Programmed Supplements NOT USED

d) Ch. 15 Electrons and the Periodic Table - Ch. 4 Programmed Supplements

i) Parts of this chapter in the Programmed Supplements are at an advanced level or use terms and quantum number designations which make it appear advanced.

It will probably be necessary to correlate the Programmed Supplement to classroom discussion by pointing out that $l = 0, 1, 2$ & 3 refers to "s", "p", "d", and "f"; $m_l = -1, 0, +1$ refers to the individual orbitals; and $m_s = \pm \frac{1}{2}$ refers to the spin of the electron. The "l", "m_l", and "m_s" will not be emphasized on the exam.

ii) All of the chapter in the Programmed Supplement is to be assigned.

e) Ch. 16 Molecules in the Gas Phase - Ch. 5 & Ch. 6 in the Programmed Supplements

i) Ch. 5 - Do only questions #1 - 56 inclusive. After question 56, the discussion of "formal charge" does not fit into the CHEM Study course.

ii) Ch. 6 - Do all of this chapter.
- Note that there are numerous references to sigma and pi bonds, otherwise the chapter should fit very well.

You can expect that the students who use the Programmed Supplements

for preview are going to have difficulties (especially "non-directed"). But then the purpose of the experiment is to find out how this affects their achievement for this chapter.

6) An attitude questionnaire (5 or 10 minutes) shall be administered to the students as a group after the first chapter and repeated after the last chapter from the Programmed Supplement.

7) The researcher will relieve the teacher of the pile of assignments handed in. These shall not be returned to the student. The teacher shall only be required to mark down that the assignment was or was not completed.

8) After going over the test with the students (after the test is corrected), the tests should be recollected so that the item analysis may be conducted by the experimenter. The tests will be returned again after the analysis.

9) Since attendance has been a problem lately, and since attendance may effect the results of the experiment, the experimenter shall also require a summary of the students' attendance to chemistry class.

10) The experimenter would appreciate any effort by teachers to obtain a complete record on all students. (i.e. having a student write an exam which he has missed.)

11) Please note down the amount of class time used (directed or non-directed) for the Programmed Supplements on the form provided.